START YOUR NIGHT SKY ADVENTURE

STARGAZING LIVE

Part of the Discover Space series

Your beginner's guide to astronomy

Find your way around the constellations

All you need to know about the stars & planets

Best sights to see with the naked eye, binoculars & telescopes

With an introduction by Brian Cox

Stargazing in the Aussie Outback

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An Introduction by Professor Brian Cox

Astronomy is the easiest science to communicate because anybody can do it, and it is immediately beautiful; the recent displays offered by Venus, Mars and the crescent Moon in the evening sky have entranced even through the glow of city lights. As with all the sciences, however, a little knowledge makes nature more beautiful. A sky full of sparkling pinpricks and dimly luminous smudges is one thing, but a sky full of worlds is quite another.

Through binoculars or a small telescope, astronomy is transformed into a powerful emotional experience. There is a feeling on seeing Saturn like a child's sketch, or the Galilean satellites shifting nightly around pastel-banded Jupiter, or the 3D swarm of The Great Cluster that's hard to describe, but we've all experienced it and it never leaves even the most experienced of observers. It's like being a passenger in a speeding car cresting the summit of a hill, continuously.

For me, the power comes from being forced to consider two seemingly irreconcilable ideas: we are tiny and fragile and insignificant, but we are also valuable. It is a remarkable thing that there are living things built out of atoms that can understand the nature of the stars and construct theories of their origins. How many of the points of light we observe in the darkness can lay claim to that? Astronomy has delivered many things of great value to our culture – the study of the motion of the planets is arguably the foundation of modern science – but I think this question is the most valuable thing of all.

Astronomy demands perspective; it requires us to consider our fragility, our value and our responsibility to protect our world. It forces us to be humble, to marvel at our good fortune, and to think of our civilization as a rare and precious island in the limitless ocean of stars. I know of no xenophobic astronomers, and this suggests to me that if the whole world were populated by astronomers, it would be a much safer and more peaceful place.

> **"Through binoculars or a small telescope, astronomy is transformed into a powerful emotional experience"**

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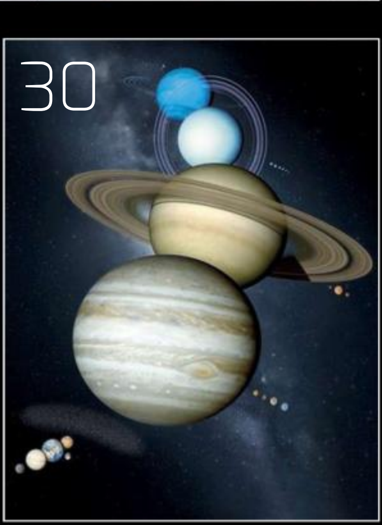

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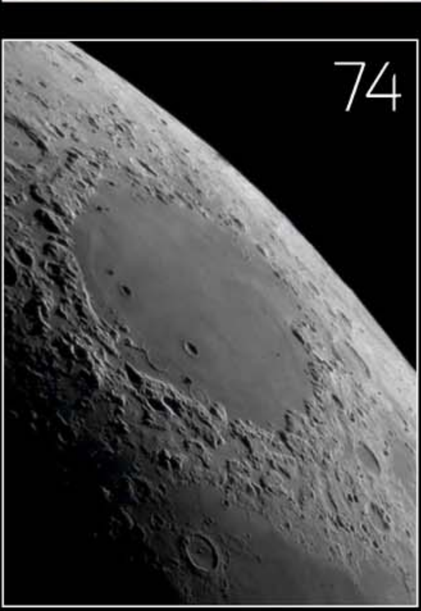
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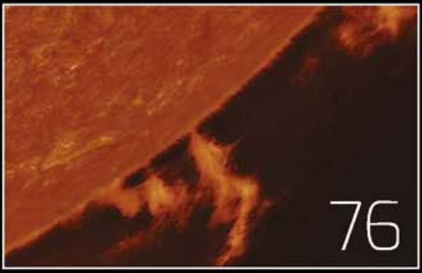
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ON LOCATION WITH STARGAZING LIVE

Discover the southern hemisphere; from the best sights in the sky to historic observatories to visit

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08 Go stargazing Aussie style for an outback adventure
12 The big debate: which hemisphere has the best sights
16 Join the team at the famous Siding Spring Observatory
18 You've seen the movie – now visit the Big Dish for yourself

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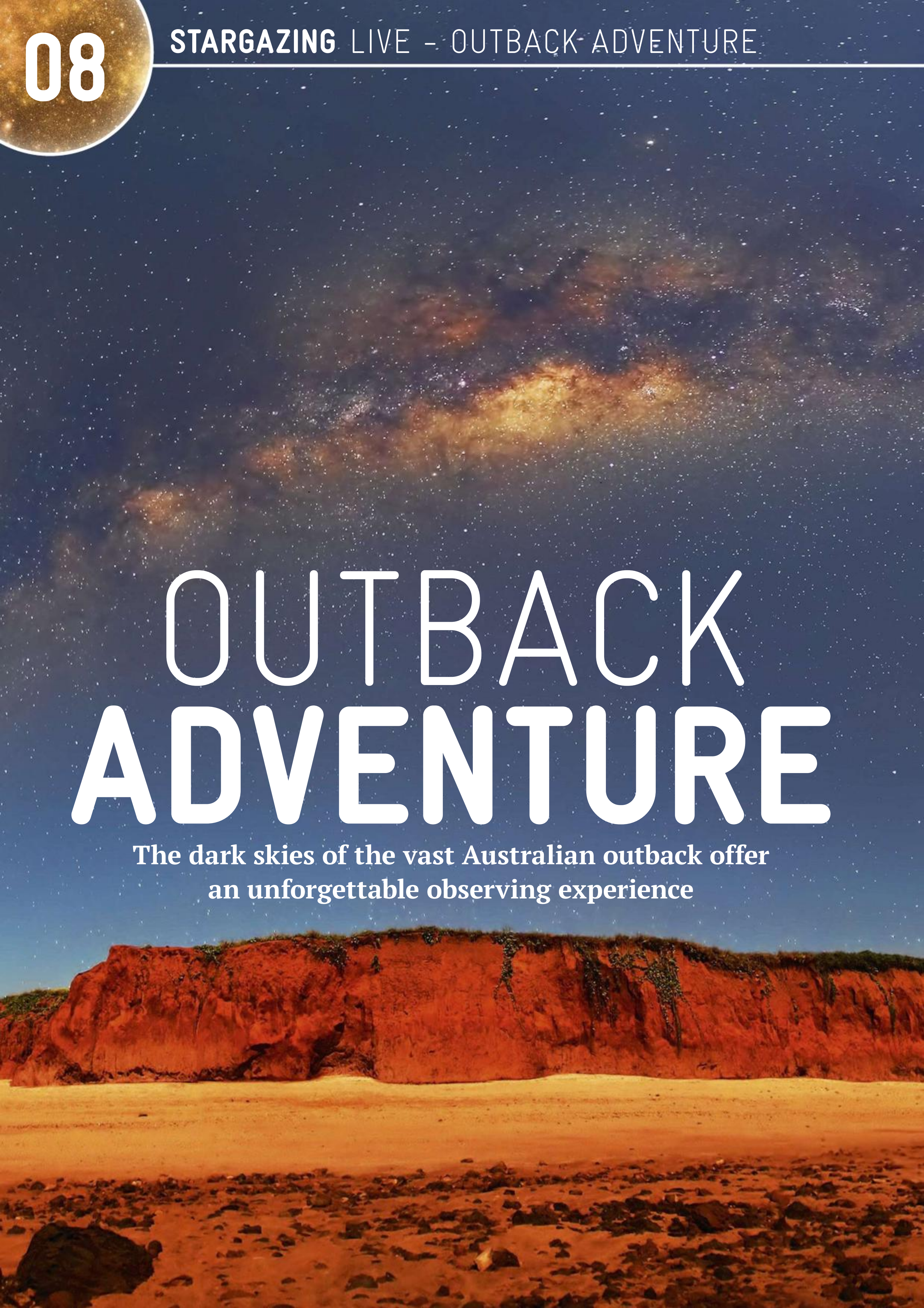


OUTBACK ADVENTURE

The dark skies of the vast Australian outback offer an unforgettable observing experience

The largely flat terrain around Broome in Western Australia presents a huge stretch of sky to explore. To some, the Milky Way, shown here, is a majestic river, along which the dead depart this world

ROD HARTVIGSEN

Australia's beautiful beaches and stunning natural wonders, like the Great Barrier Reef, Ayers Rock and the Twelve Apostles, are more than enough to tempt curious travellers. Yet for amateur astronomers there is another great appeal – observing the southern sky. With a population of less than 23 million (around a third of the UK's) and a land mass so large that much of Western Europe could easily fit inside it, there is little light pollution. Most of the country's major towns and cities are clustered on the coast, so head inland into the red desert of the outback and there is barely a soul – or a light – to be seen.

The Large and Small Magellanic clouds are well worth a look if you have the right equipment

SOUTHERN DELIGHTS

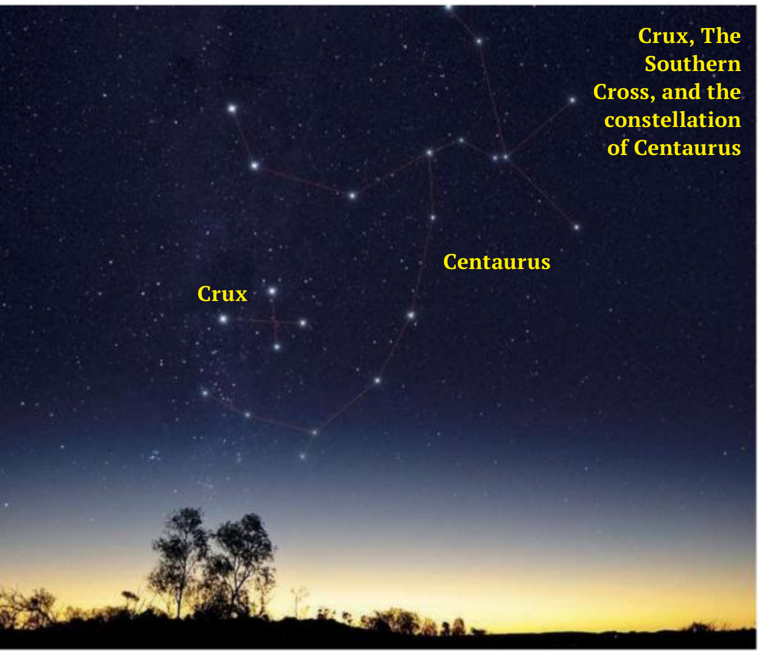
With so little light pollution you don't even need a telescope to appreciate many of the wonders of the southern hemisphere night sky – there are so many stars visible against the blackness of space.

"It's consistently excellent in the outback," says Aussie astronomer and astrophotographer Greg Quicke. "There is very little light pollution and no air pollution, which gives amazing access to the night sky."

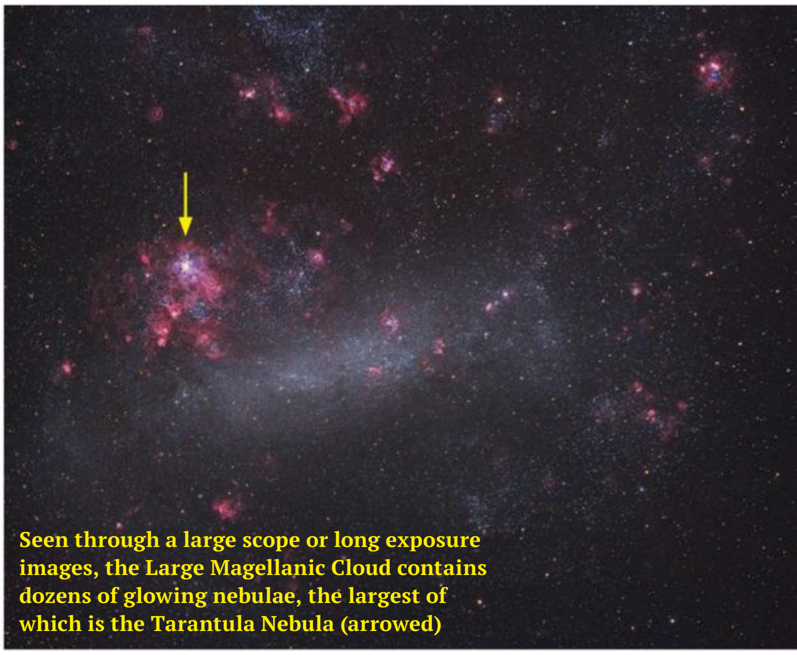
Top of Quicke's checklist of the best the southern hemisphere has to offer are the globular clusters that largely sit below the horizon from northern skies. These spherical collections of stars orbit a core and are held together by gravity; look for the glorious globular clusters Omega Centauri and 47 Tucanae.

SIGNPOST SOUTH

Top constellations for amateurs learning to navigate the southern hemisphere sky



Crux, The Southern Cross, and the constellation of Centaurus



Seen through a large scope or long exposure images, the Large Magellanic Cloud contains dozens of glowing nebulae, the largest of which is the Tarantula Nebula (arrowed)

It's relatively easy to find objects in the southern hemisphere, especially along the band of the Milky Way. There are plenty of stars down to around magnitude +5.0 to help point a telescope. Moving towards the Galactic Pole can sometimes become a test of your star-hopping skills but this is the same in the northern hemisphere too.

If you need to polar align a telescope this can be a challenge in the southern hemisphere – there isn't a Polaris to get you close to the Celestial Pole. However, you can find a rough position by extending the axis of the Crux constellation from Gamma through Alpha out to five times its length.

Finding your way around the Magellanic Clouds can also be tricky. They contain a feast of faint nebulae and clusters, which are often only listed in obscure catalogues. Even if you use a Go-To scope that has a good database, your field of view may contain many candidates for your object. It takes only a moderate 10-inch telescope to get lost but perseverance will pay off.

WHERE TO GO AND WHEN

As Australia is so big, the country has a number of different climates. Much of the south experiences seasons similar to those in the UK, while a lot of the north is more tropical with wet/dry seasons.

In the south, the winter months of June to August give the best observing conditions. In the tropics, the six-month long dry season from April to October allows for perfect observing conditions as there is little chance of rain.

The weather isn't as favourable in the tropical wet season, which runs from November through to April, but good observing conditions persist for around 300 days of the year nonetheless.

Although days can be very warm, clear skies mean temperatures can drop rapidly at night. It may be 30°C or more while the Sun shines but don't be fooled – you will be glad of a warm coat and a pair of gloves at night.

Australia's climate is extremely diverse and encompasses everything from the aridness of Kings Canyon found in central Australia (left), to lush forested areas like Black Spur Drive in the southern state of Victoria (right)

Other celestial delights include constellations such as the Southern Cross (the smallest of the 88 modern constellations), the Southern Pleiades, the Large and Small Magellanic Clouds and NGC 3242, a beautiful blue-green planetary nebula. Known as the Ghost of Jupiter or the Eye Nebula, NGC 3242 can easily be spotted through a telescope. The beauty of the Milky Way will really take your breath away, too.

A NEW WAY OF SEEING

The Yolngu people believe that the Milky Way is a great river along which they are transported by canoe after death. Indeed, Aborigines have special terms for the constellations and other sights in the night sky, many of which are included in their creation stories.

Even if you are familiar with the night sky in the northern hemisphere, seeing the southern sky for the first time is something of an alien experience. There are so many things you expect to see but don't, even familiar objects are not where you instinctively look for them, or they might look different – for example, Orion is visible on the horizon early in the evening, but it is upside down.

It is the promise of these unique celestial wonders and pristine skies that brings so many northern hemisphere observers to the land down under. Astronomy tourism is becoming increasingly popular in Australia with over 10,000 people a year now taking part in tours run by astronomy groups around the country. Joining them is sure to be a remarkable experience.

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⮝ NGC 3242, The Ghost of Jupiter, is also known as the Eye Nebula

⮝ Gravity gives the globular cluster Omega Centauri its spherical shape

⮝ The Southern Pleaides, about 479 light years away, can be seen with the naked eye

THE BIG DEBATE

Turn to page 42 to find out about galaxies, nebulae and star clusters

North or south – which half of the night sky has the best celestial sights? Here are some of the gems each hemisphere has to offer so you can decide…

NEBULAE

NORTH

The northern hemisphere has some bright planetary nebulae, such as the glorious Dumbbell Nebula, M27, the Ring Nebula, M57, the Cat's Eye Nebula and the Blue Snowball. You can have some serious fun hunting for the Blinking Nebula, too – look directly at it and it will seem to disappear, then switch to averted vision (where you don't look directly at the nebula) and it reappears. It's like playing hide and seek in the sky!

Supernovae remnants give us the Crab Nebula, M1, and the Veil Nebula in Cygnus – a beautiful slash across the blackness of space. The magnificent Orion Nebula, one of the most studied objects in the night sky, also provides a wealth of detail when viewed with both the naked eye and telescopes.

The Orion Nebula, M42, is located south of Orion's Belt and is the closest area of massive star formation to Earth

◄ M27, the Dumbbell Nebula, can be seen through large binoculars and is best observed in the summer

SOUTH

The southern hemisphere has some impressive nebulae. Eta Carinae, NGC 3372, features a prominent 'L'-shaped dark cloud, within which lies the inky silhouette of the Keyhole Nebula. Next to this is Eta's 'twin-lobed', Homunculus Nebula, two balloon-shaped shells of gas and dust joined in the centre. With a 6-inch telescope you'll be able to see the 'legs' of the celestial arachnid – the Tarantula Nebula in Dorado. Centaurus, the planetary nebula NGC 3918, is a striking blue marble and the Emu is an asterism made up entirely of dark nebulae, a mix of dust and gas that emits no light itself but is observable because it blocks light from other sources. The Emu's head is the Coal Sack Nebula, his neck extends along the Milky Way and the central hub of the Milky Way makes up his body.

▲ The torrent of ultraviolet light and stellar winds released by the bright stars in the Tarantula Nebula is actually eroding away the hydrogen gas cloud in which these stars were born

▲ The Eta Carina Nebula contains many smaller nebula and is larger and even brighter than the Orion Nebula

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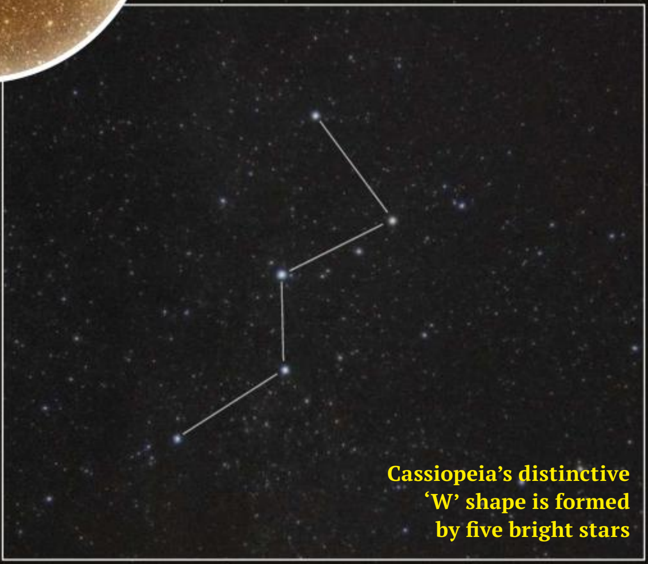


Cassiopeia's distinctive 'W' shape is formed by five bright stars

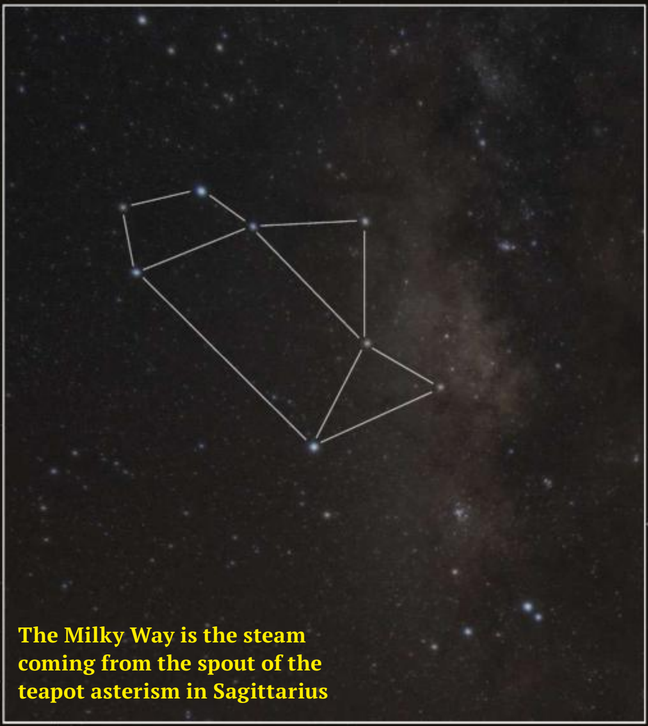
CONSTELLATIONS

NORTH

To look at the skies in the northern hemisphere is to be captivated by the fantastic stories of Greek and Roman mythology. Indeed, there are a wide range of distinctive constellations: Perseus, Andromeda, Cepheus, Pegasus, 'the Queen' Cassiopeia who creates a 'W' in the sky, Leo who lords it over the skies and the great hunter, Orion, who strides across the heavens in all his majesty. Two of the stars of Ursa Major conveniently point to the Pole Star and then there's Cygnus, the Northern Cross.

SOUTH

The southern hemisphere also has a definitive cross – Crux, the Southern Cross – which can be seen for much of the year as the constellation sits above the horizon from most of Australia. Also to be marvelled at are the constellations Scorpius (which really looks like its namesake) and Sagittarius with its teapot-shaped asterism. And don't miss the brightest star in the sky – Sirius.



The Milky Way is the steam coming from the spout of the teapot asterism in Sagittarius

STAR CLUSTERS

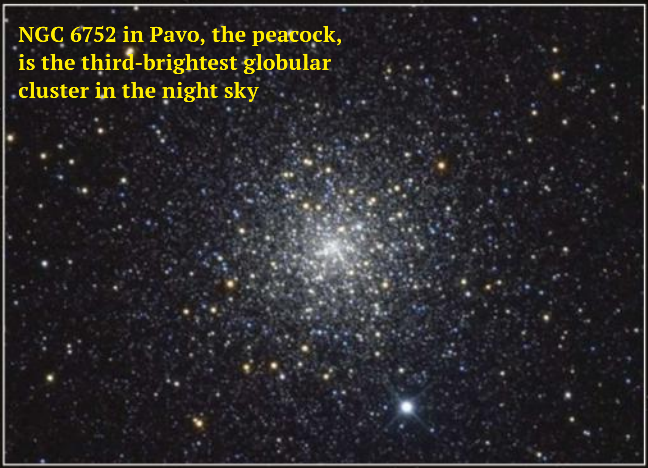
In clear, dark conditions you could spot the nebulosity the Pleiades is embedded in

NORTH

The Pleiades open star cluster, M45, in Taurus is an impressive sight, observable from suburban as well as dark skies. Its seven stars visible to the naked eye grow to dozens with binoculars. But there are other spectacles too: from the wonderful Beehive Cluster, M44, to the Coathanger Cluster and the haze of stars that make up Melotte 111 in Coma. As for globular clusters – M13 in the constellation of Hercules is a stunner and M3, M5 and M15 all overflow with stars. Don't miss the Galactic Wanderer, NGC 2419 – one of the furthest globulars on record. Or why not really push the limits by observing a few globulars around the Andromeda Galaxy, a mere 2.3 million lightyears away!

SOUTH

The southern skies also have some incredible globular clusters – 47 of the top 50 brightest are in the southern hemisphere. Egg-shaped Omega Centauri has delicate dark lanes and 47 Tucanae is so packed with stars it can be seen with the naked eye. Look for it next to the Small Magellanic Cloud, a dwarf galaxy near the Milky Way. The globular cluster NGC 6752 in Pavo, the peacock, resembles a brilliant open cluster overlying a background globular haze. NGC 6397 in Ara and NGC 2808 in Carina are also impressive, as are the 15 Messier globulars that reside in Ophiuchus, Scorpius and Sagittarius. For stunning open clusters, the Jewel Box in Crux has a lovely central ruby red star and the constellation of Carina is a nest of open clusters, with NGC 2516 and IC 2602 both visible to the naked eye.



NGC 6752 in Pavo, the peacock, is the third-brightest globular cluster in the night sky

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MULTIPLE AND VARIABLE STARS

Albireo is known for the striking contrast between its gold and blue stars

⋀ NORTH

The double star Albireo, in the Northern Cross Cygnus, is a gorgeous gold and blue combination that can be split even with binoculars. Algieba in Leo sparkles away with two golden-yellow suns, while Epsilon Lyrae, the 'Double Double' (itself two stars in one), is also truly lovely. For a 'variable' star (one that changes in brightness) that you can spot with the naked eye, try the Demon Star Algol, or perhaps the most important variable in the sky, Delta Cepheus, whose variability helped scientists measure distances in the Universe. Then there's Polaris, the North Star, which is both a variable star and a double star.

⋁ SOUTH

The southern hemisphere's brightest double star is Alpha Centauri; its brilliant 'headlights' outshine other multiple stars. Other double stars that only need a small telescope to split are Alpha Circinus, Gamma Volantis, Upsilon Carinae and the wonderful Alpha Crucis and Gamma Velorum. If you are looking for variable stars, L2 Puppis, with its range of brightness, is ideal for binoculars. Another southern gem is V854 Centauri, an active little star which releases clouds of soot, blocking its light. The ultimate variable star has to be the supernova 1987a in the Large Magellanic Cloud, the closest supernova since 1604 and visible in the south with the naked eye.

Alpha Centauri is the closest star system to the Solar System

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You can hunt globular clusters in the Andromeda Galaxy, M31, it's so close

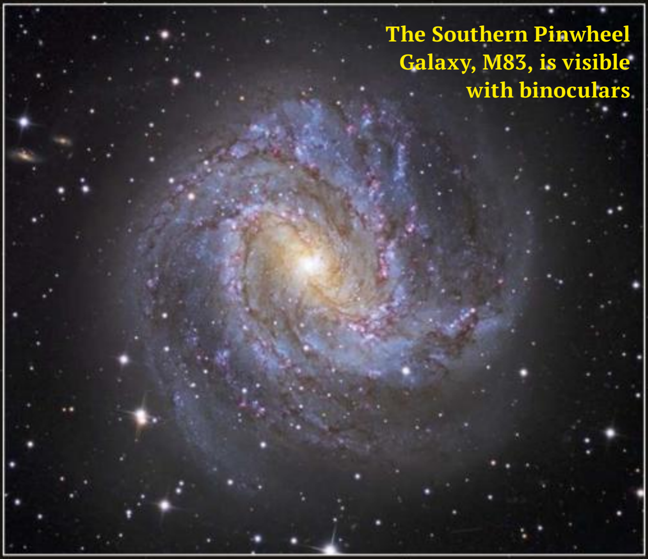
GALAXIES

⋀ NORTH

The northern hemisphere is home to some quality galaxies. The Andromeda Galaxy is so close you can hunt globular clusters in it. For edge-on spiral galaxies take a look at the 'Realm of Galaxies' that sits in Coma. Face-on galaxies include the Pinwheel, M101, and the Triangulum Galaxy, M33, which has its own nebulae, such as NGC 604. At least 2 billion lightyears away is 3C 273 – the brightest quasar visible through backyard telescopes. The first quasar ever to be identified, this supermassive black hole shines incredibly brightly as it consumes cosmic matter at such a fierce rate.

⋁ SOUTH

While the number of galaxies visible in the southern hemisphere may be lower, it more than makes up for this in quality. Firstly, the big guns: the Large and Small Magellanic Clouds, two dwarf galaxies thought to be satellites orbiting the Milky Way. Centaurus is home to two more large galaxies: the seventh-magnitude Hamburger Galaxy, NGC 5128, with its distinct dark equatorial band and NGC 4945, a dazzling edge-on spiral galaxy. Hydra offers one of the best face-on spiral galaxies, the Southern Pinwheel Galaxy, M83. The Fornax Cluster of galaxies includes the mysterious 'S'-shaped barred spiral NGC 1365.



The Southern Pinwheel Galaxy, M83, is visible with binoculars

LIVE ON LOCATION

This year, the *Stargazing Live* team visit Siding Spring Observatory in the remote New South Wales outback

Some of the most awe-inspiring sights in the night sky are only visible from the southern hemisphere, which is why one of the world's best known and most productive observatories is situated in the Australian outback.

The Siding Spring Observatory is located in the Warrumbungle Mountains in New South Wales, 40km from the town of Coonabarabran, which is itself 500km northwest of Sydney. The site is dominated by the huge 37m-wide dome of the Anglo-Australian Telescope (AAT), which is slightly larger than the one at St Paul's Cathedral. A 4m telescope has operated there for well over 30 years.

Astronomer and astrophotographer David Malin took many well-known images with this telescope, riding in the prime focus cage at the top of the scope to expose photographic plates. Each of his colour images were the combination of three black and white plates taken through red, green and blue filters; incredibly each individual plate took up to an hour to expose fully.

◀The huge dome of the Anglo-Australian Telescope dominates the landscape

A NEW ERA IN DESIGN

The instrumentation has been kept up to date and the telescope still performs unique scientific work, both in visible and infrared light. One example is the planet-search programme carried out using a spectrograph built at University College London. This has discovered many planets around nearby stars, contributing to our understanding of quite how unusual our own Solar System is.

The AAT marked the end of an era in telescope design, as it was one of the last large telescopes built with an

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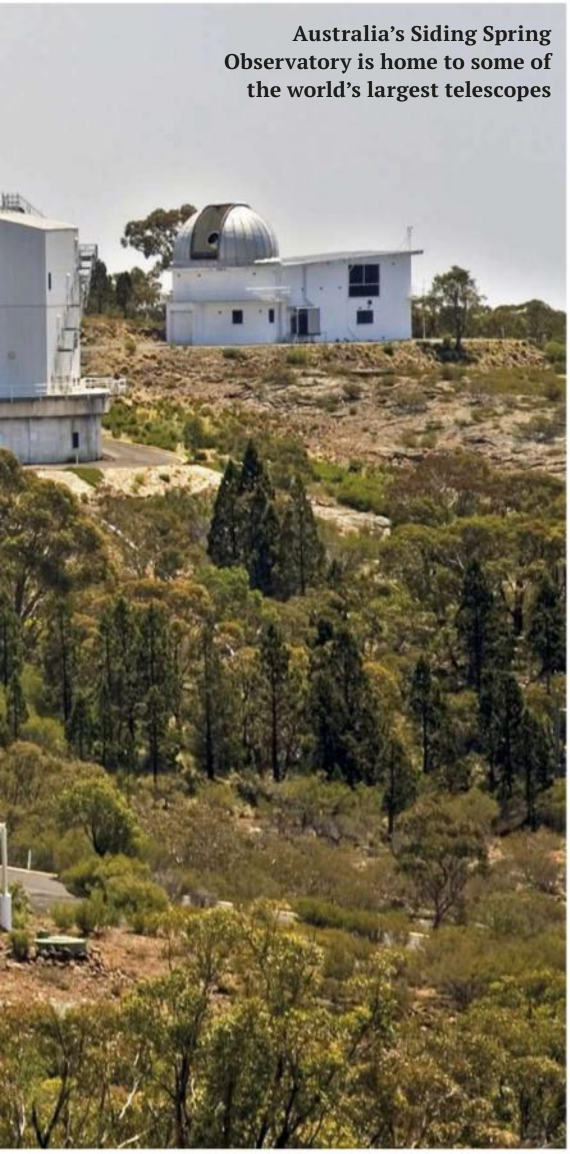

Australia's Siding Spring Observatory is home to some of the world's largest telescopes

THE ANGLO-AUSTRALIAN TELESCOPE

Weight of dome 560 tonnes
Weight of mirror 16.2 tonnes
Weight of mirror coating 2.5g
Tube length 15m
Mirror thickness 63cm
Height above sea level 1,134m
Clear skies 237 out of 365 nights
Inaugurated 1974 by Prince Charles
http://rsaa.anu.edu.au/observatories/siding-spring-observatory

◄ The UK Schmidt telescope has created a 3D map of the galaxy

equatorial mount – a horseshoe-shaped fork in which the telescope sits. Its neighbour, the Advanced Technology Telescope (ATT) was constructed in the early 1980s and marked the beginning of a new style of telescope design.

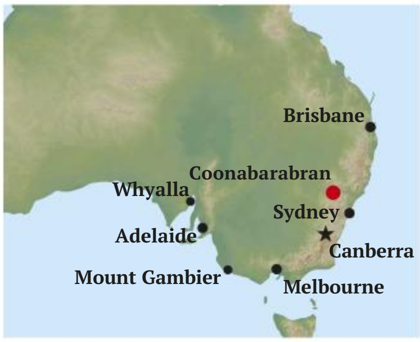
The ATT was the first to incorporate three features that are now fitted as standard on modern telescopes. Firstly, the mirror is extremely thin in order to make cooling easier – necessary to ensure a sharp focus. Secondly, the mount is not an equatorial but an altazimuth mount: a two-axis mount for supporting and rotating the scope about two perpendicular axes – one vertical and one horizontal. Although these mounts employ more complicated movements to follow objects across the sky, advances in computing power have made this a possibility. Finally, the ATT's entire building rotates, rather than just the dome.

Other telescopes on the site include the 1.2m UK Schmidt telescope, which has helped astronomers to create a 3D map of our entire Galaxy, and the 2m Faulkes South Telescope, which can be operated robotically or via the web and is used by schools and colleges to perform scientific experiments. The University of New South Wales also has a patrol scope, which sweeps the skies for near-Earth asteroids, and there are three historic small refractor scopes, the largest of which has a 1m diameter.

The site is also host to 10 telescopes on the iTelescope network; which you can access online from your home computer. If you can't make the trip to Siding Spring, this service offers you the chance to see the southern skies and have a go at astrophotography too. Find out more at **www.itelescope.net**.

VISIT

For information on guided tours go to **www.nationalparks.nsw.gov.au/things-to-do/guided-tours/siding-spring-observatory-tour**



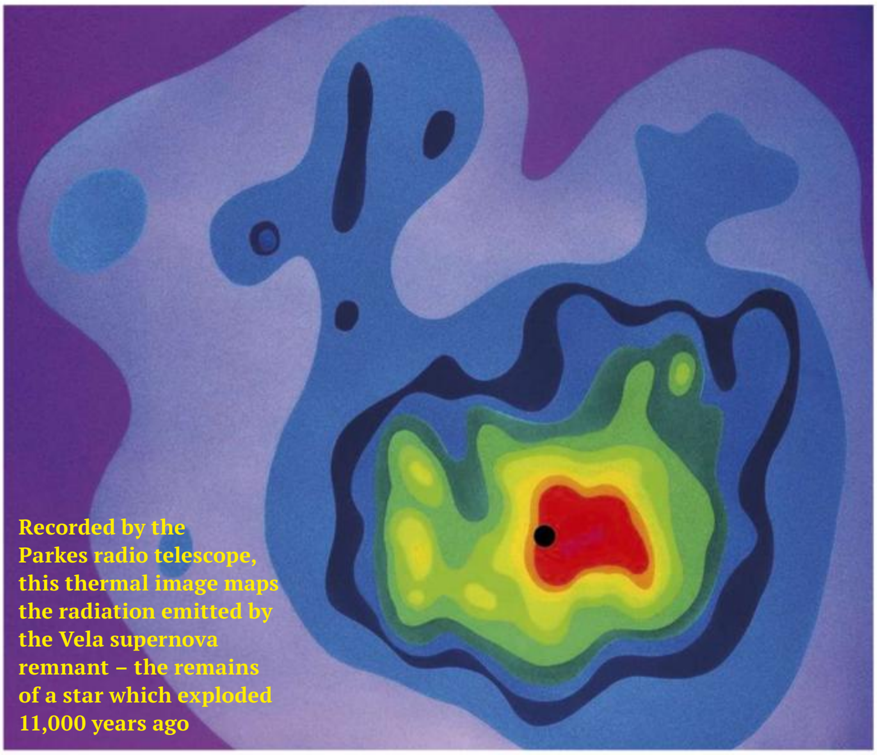
THE BIG DISH

Australia's place in radio astronomy was established by this iconic landmark over 56 years ago

As it swivels across the night sky, Parkes radio telescope is visible from many kilometres away, sitting as it does in the wide, open plains of the New South Wales outback, 320km west of Sydney.

It's been a huge part of Aussie culture for decades, for many years appearing on the local $50 banknote. But it has also gained global recognition for its many astronomical discoveries, and for the film *The Dish*, which was based on the telescope's role in receiving signals from the first manned Moon landing.

It's no surprise, then, that every year more than 100,000 visitors make a detour from the nearest highway to see this attraction, despite its relative isolation. An odd sight it is too, appearing like a stubby lighthouse with a huge white bowl stuck on top. For rather than having supports at the sides of the dish, as would seem more logical for stability, they are positioned on the inside. This design, with the pivot at the middle of the great bowl, has some drawbacks. Its



Recorded by the Parkes radio telescope, this thermal image maps the radiation emitted by the Vela supernova remnant – the remains of a star which exploded 11,000 years ago

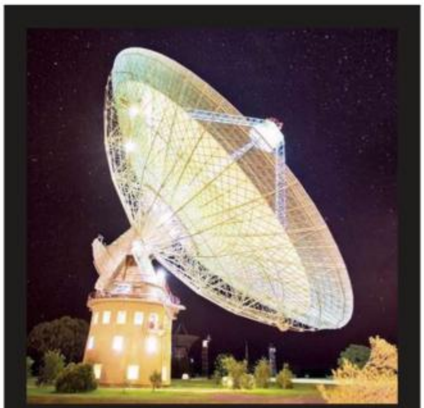
operating rules state that the telescope should be safely 'parked' when wind speeds exceed about 22mph, but when Apollo 11 landed on the Moon the wind was gusting at over three times that limit. The observatory director at the time, John Bolton, gritted his teeth and ordered tracking to continue. The rest is history – and the basis for a good movie!

NASA'S PROTOTYPE

With a diameter of 64m, the telescope was the largest in the southern hemisphere until it was overtaken by the main dish at NASA's space tracking station at Tidbinbilla, just west of Canberra, in 1965. When Parkes was completed in 1961 the era of space exploration was just beginning and it became the prototype for NASA's Deep Space Network that involved Tidbinbilla, Goldstone in California and Madrid in Spain.

When the epic era of radio astronomy was starting out back in the 1950s, Australia established itself as a leader, owing to its radar experience during WWII. It was the first southern nation to venture into this field. Several radio observatories operating at wavelengths greater than one metre (consisting of fields of wires rather than steerable dishes) were built, made important discoveries and then decayed away.

Parkes, however, was the first of its type in the southern hemisphere, a big dish making observations at centimetre wavelengths, with excellent engineering. With such strong and continued support from the government, the result is a much-loved national icon that continues to deliver exciting results today.



THE PARKES RADIO TELESCOPE

Built In 1961 for radio astronomy at wavelengths of 20–70cm

Dish size 64m across

Upgrades New surface enables observations down to 1cm

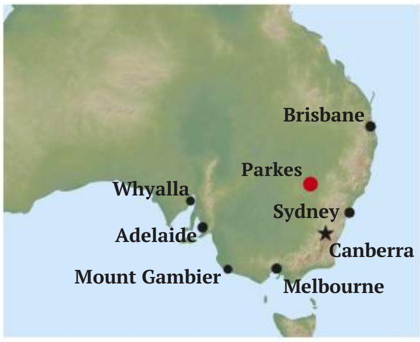
Operation Stand-alone or in an array for interferometry

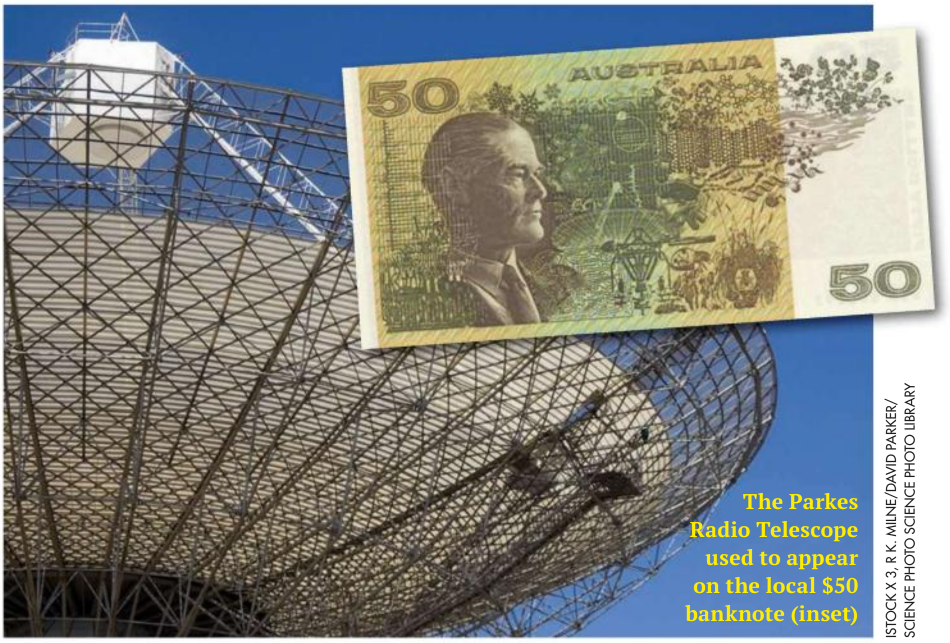
Signals received from The Apollo missions, Galileo at Jupiter and Voyager 2 at Uranus and Neptune

Major contributions Mapping the southern sky at different radio frequencies; charting interstellar molecular clouds; identifying galactic magnetic fields; pulsar discoveries and the detection of the most distant known quasar

VISIT

For information on visiting the Parkes radio telescope go to **www.atnf.csiro.au/outreach/visiting/parkes/index.html**





The Parkes Radio Telescope used to appear on the local $50 banknote (inset)

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August's American eclipse and 11 other great dark sky getaway ideas for 2017
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Understanding the basics of astronomy and the night sky will help you to make sense of the Universe as you observe its many marvels

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THE STARRY SKY

There are patterns in the skies that have been observed, and made legends of, for millennia

BERNHARD HUBL/ CHRISTOPH KALTSEIS/ WOLFGANG LEITNER/ HERBERT WALTER/CCDGUIDE.COM, ISTOCK X 8

There are all sorts of celestial bodies to see in the night sky: the famous planets, wispy nebulae, far-flung galaxies and occasional visitors like comets and meteors. But it is best to start with the stars themselves. All of the individual stars that you can see exist within our Galaxy, the Milky Way, which is home to around 200 billion stars in all.

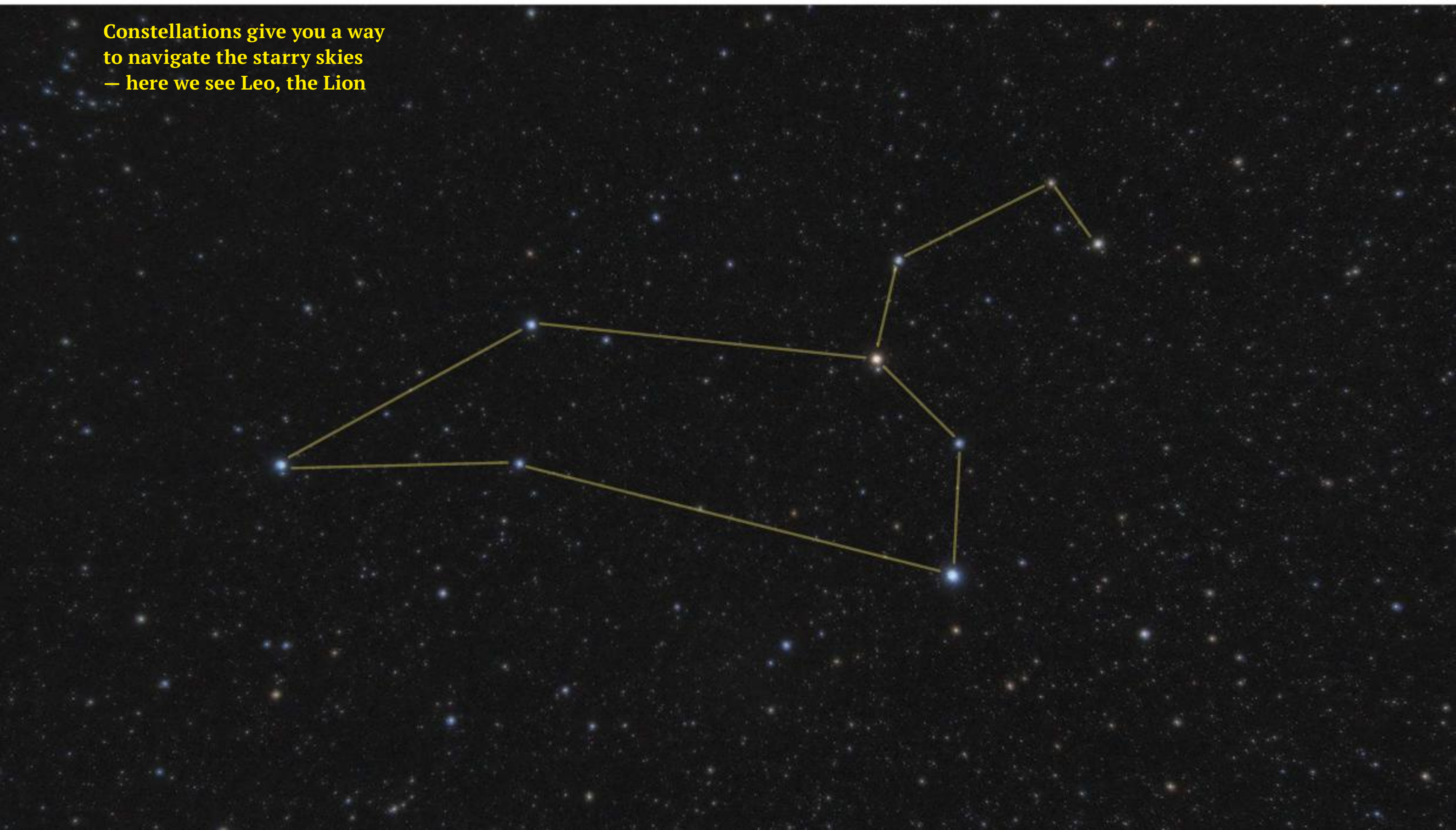
Stars are immense balls of electrically charged gas in which nuclear fusion reactions take place. The transformation of light elements into heavier ones, such as hydrogen into helium – and on through successive cycles of reactions into carbon, nitrogen, oxygen and eventually iron – releases the energy that causes a star to shine.

If you scan across the night sky you'll notice that the stars don't all shine with the same brightness, nor are they all the same colour, but a glittering array of rich golds, warm oranges, glinting sapphires and angry reds. The fact that we see different colours is down to each star's surface temperature: the hotter it is, the bluer the light it emits. Stars become more yellow in the middle of their lives and eventually red as they begin to exhaust their fuel and cool down.

STAR PATTERNS

The sky is split into zones called constellations, each of which is based on a pattern of stars that is said to resemble an object, an animal or a figure from folklore or mythology. Some of these patterns need a bit of imagination to make out what they are named after. The stars that form the shape that gives each constellation its name are not necessarily related to each other – in fact many of them are vast distances apart; they only appear close in the sky from our perspective on Earth.

There are 88 recognised constellations in modern astronomy and every celestial object can be found within a constellation.



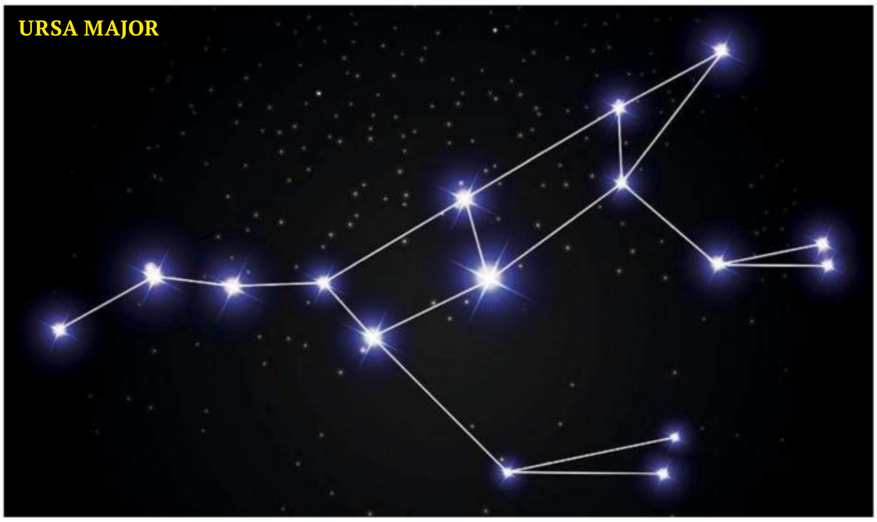
Constellations give you a way to navigate the starry skies — here we see Leo, the Lion

For objects beyond the Solar System, such as galaxies and nebulae, the constellation is 'fixed' – they will always appear to be in that one constellation. Things within the Solar System, such as the Moon and planets, appear to move across the constellations.

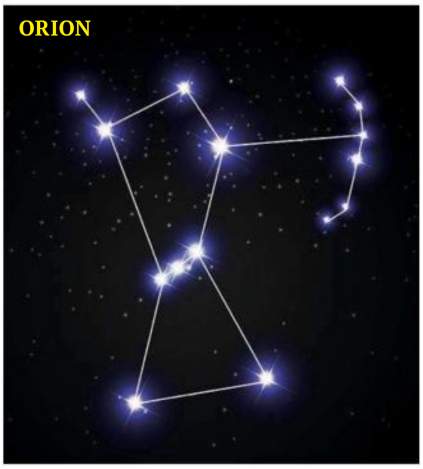
Particularly bright and easily identifiable star patterns are known as 'asterisms', and they can be comprised of stars within a single constellation or span several. It's these brighter patterns that astronomers use as 'signposts' to help them identify other stars and find their way to the faint objects of the deep sky.

STARTER STAR PATTERNS

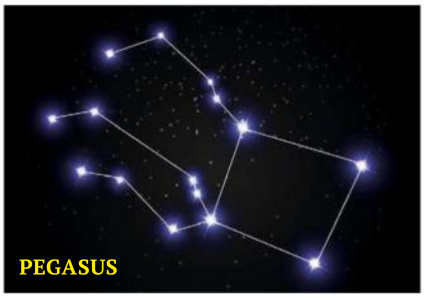
Key constellations for amateurs exploring the northern hemisphere


URSA MAJOR

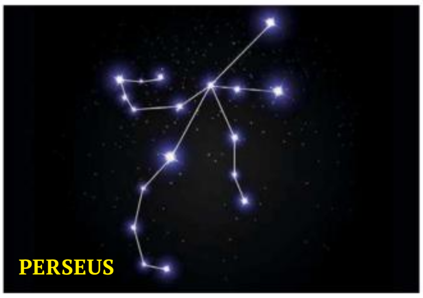
Represents: The nymph Callisto, transformed into a large bear by Jupiter's jealous wife
Best time to see from UK: All year
Home to: The Plough asterism; easy to split double star Mizar and Alcor


ORION

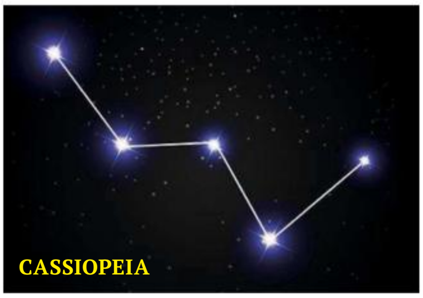
Represents: Orion, a gifted hunter, son of Poseidon and the Gorgon Euryale
Best time to see from UK: December to March
Home to: The spectacular Orion Nebula and the Orion's Belt asterism


PEGASUS

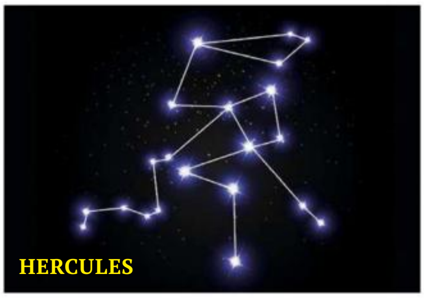
Represents: A winged horse, offspring of Poseidon and Medusa, ridden by Bellerophon
Best time to see from UK: August to December
Home to: The Great Square asterism


PERSEUS

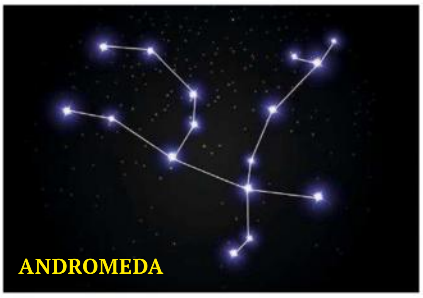
Represents: The Greek hero Perseus
Best time to see from UK: August to April
Home to: Algol, a great beginners' variable star; the radiant of the Perseid meteor shower


CASSIOPEIA

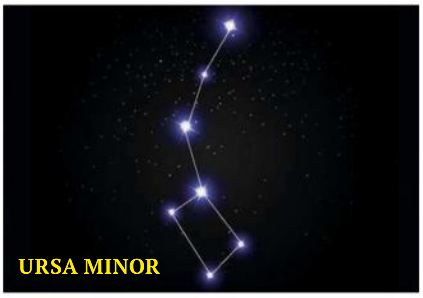
Represents: The queen Cassiopeia, mother to Andromeda, sent to the sky as a punishment
Best time to see from UK: All year
Home to: The 'W' asterism


HERCULES

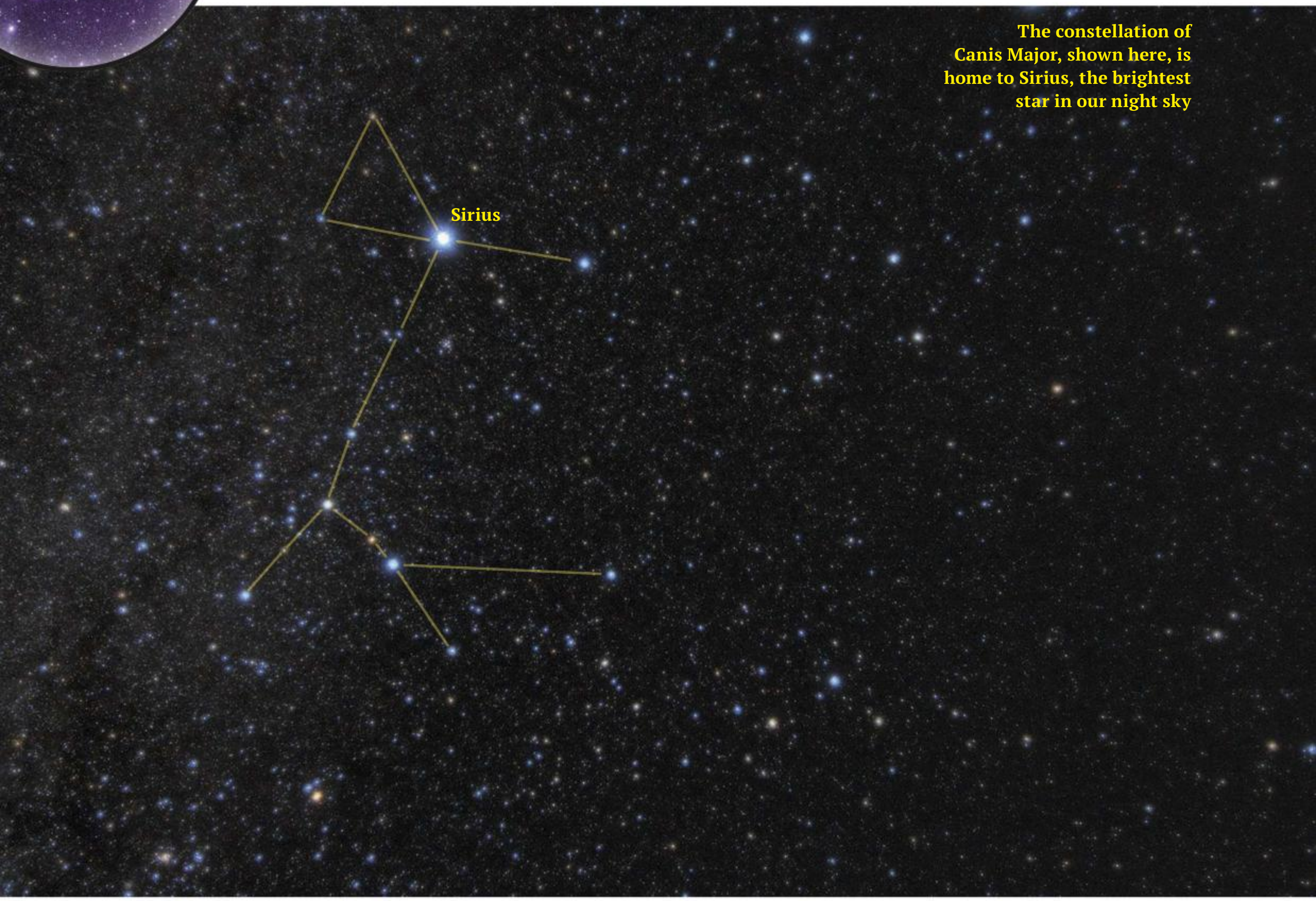
Represents: The Roman hero adapted from the Greek Heracles, with his club raised
Best time to see from UK: April to October
Home to: M13, the brightest globular cluster in the northern hemisphere


ANDROMEDA

Represents: The princess Andromeda, chained to a rock to be eaten by Cetus
Best time to see from UK: August to December
Home to: M31, the Milky Way's 'big brother' galaxy, 2.5 million lightyears away


URSA MINOR

Represents: Arcas, son of Zeus and Callisto, turned into a small bear by jealous Hera, the goddess of women and marriage
Best time to see from UK: All year
Home to: Polaris (the Pole Star)



The constellation of Canis Major, shown here, is home to Sirius, the brightest star in our night sky

STAR LIGHT
STAR BRIGHT

Knowing that not all stars are the same brightness helps to navigate the night sky

BERNHARD HUBL/ CHRISTOPH KALTSEIS/ WOLFGANG LEITNER/ HERBERT WALTER/CCDGUIDE.COM, ISTOCK

Looking at the night sky, it is instantly obvious that not all stars shine the same. How bright a star looks is called its 'apparent visual magnitude', or 'mag.'. What's strange about magnitude scales is that the numbering system is back to front – the brighter the star, the lower the number it is given. So a star of mag. +2.0 is therefore brighter than one that's mag. +5.0. Why the plus sign? This is because there are stars brighter than zero – in other words, the scale extends into negative numbers.

To understand why, we have to cast our minds back more than 2,000 years and think about how the ancient Greeks tried to make sense of the heavens. Back then, astronomer and mathematician Hipparchus called the variation in star brightness 'magnitude', and arranged the stars into six groups, labelling the brightest stars as being of 'the first magnitude', slightly fainter stars as second magnitude, and so on down to sixth magnitude – the faintest stars that can be seen with the naked eye alone.

The telescope hadn't been invented back then. Nowadays, not only can we see much fainter celestial objects than Hipparchus could, but we have also been able to more accurately measure and refine Hipparchus's original magnitudes. The basic system that he invented remains intact, but the mixing of old and new has led to some interesting changes.

SHINING SIRIUS

We now consider the mathematical difference between one magnitude and the next to be about 2.5 times in brightness. What this means is that a first magnitude star is 100 times brighter than a sixth magnitude star. In the process, astronomers realised that some of the stars in Hipparchus's first magnitude group were wildly different in brightness, and so the scale had to be extended upwards into negative numbers. Hence, the brightest star in the night sky, Sirius in the constellation of Canis Major, is mag. -1.5.

The bottom of the scale is now open-ended, growing as we find fainter and fainter stars – a 6-inch amateur scope can reveal objects as dim as mag. +13.0, while the Hubble Space Telescope has seen celestial bodies of mag. +31.0.

Hipparchus envisaged the magnitude system as a way of categorising stars, but today we apply it to all celestial bodies. The planet Venus can be as brilliant as mag. -4.5, the full Moon mag. -12.7 and the Sun an intense mag. -26.8.

But the 'apparent magnitude' tells us nothing about how luminous an object truly is – its 'absolute magnitude'. Brightness decreases with distance, so a very luminous star a long way away may appear fainter than a dimmer star that sits closer to us. For example, if Sirius were the same distance from Earth as the Sun, it would appear brighter than our star.

To calculate an object's absolute magnitude, scientists work out how bright it would be if it were an arbitrary distance of 10 parsecs – 32.6 lightyears – away. By lining up celestial objects like this, we can 'see' how they differ from one another.

TOP 10 BRIGHTEST

Look out for the most brilliant bodies in the northern hemisphere's night sky

THE MOON
Magnitude: –12.7

VENUS
Magnitude: –4.5
(at its brightest)

MARS
Magnitude: –2.9
(at its brightest)

JUPITER
Magnitude: –2.8
(at its brightest)

MERCURY
Magnitude: –1.9
(at its brightest)

SIRIUS
(Alpha Canis Majoris)
Magnitude: –1.5

SATURN
Magnitude: –0.2
(at its brightest)

ARCTURUS
(Alpha Boötis)
Magnitude: 0.0

VEGA
(Alpha Lyrae)
Magnitude: 0.0

CAPELLA
(Alpha Aurigae)
Magnitude: +0.1

A MOVING PICTURE

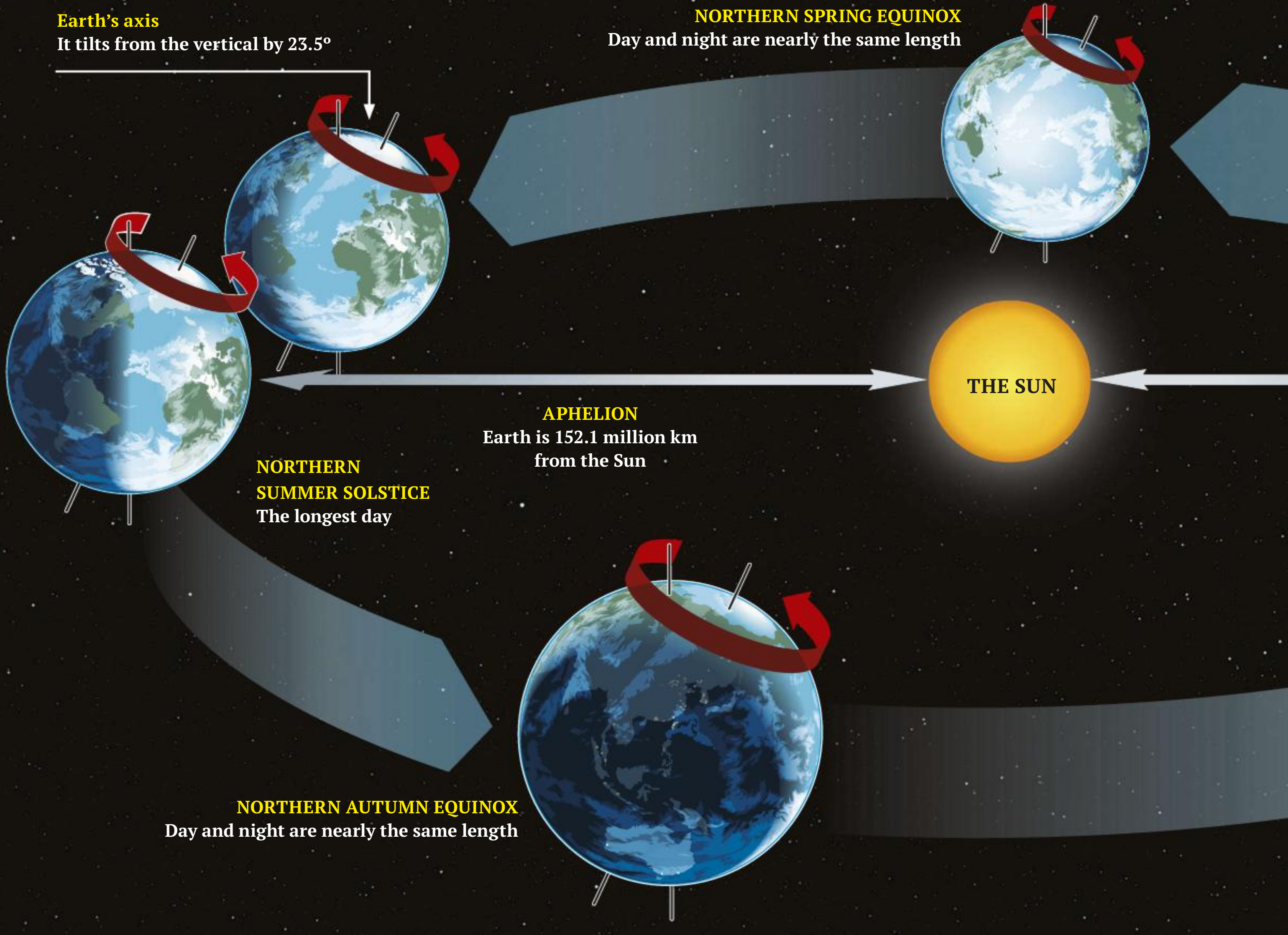
As Earth spins on its axis the stars appear to march across the sky

Until the early 1600s, people believed that the Sun orbited the Earth – they called it the geocentric model. Of course, we now know that the Earth orbits the Sun – the heliocentric model – and Earth spins on its axis, giving the impression that the Sun and other celestial objects move across the sky.

A solar day is the time it takes our planet to complete one rotation on its axis relative to the Sun, which lasts for 24 hours. A year is the time it takes for Earth to complete an orbit of the Sun.

Many people think that Earth experiences seasons because of its changing distance from the Sun. The distance between Earth and the Sun does change, as our planet's orbital path is slightly elliptical (like a squashed oval) rather than circular, which leads to a difference of 5 million km between Earth's closest point to the Sun (perihelion), and its farthest (aphelion) – but you might be surprised to know that during northern hemisphere winter, Earth is as close to the Sun as it can get: perihelion is around 3 January.

The seasons are due to the tilted axis Earth spins on as it moves around the Sun, so the length of time sunlight hits each hemisphere changes


Earth's axis
It tilts from the vertical by 23.5°
NORTHERN SPRING EQUINOX
Day and night are nearly the same length
THE SUN
APHELION
Earth is 152.1 million km from the Sun
NORTHERN SUMMER SOLSTICE
The longest day
NORTHERN AUTUMN EQUINOX
Day and night are nearly the same length

throughout the year. Model globes of Earth show this: they lean by 23.5° from the vertical.

POLES APART

On the day that the north pole is tilted 23.5° towards the Sun, the south pole points away at the same angle. For the northern hemisphere, the day this happens is the longest in terms of daylight hours (the summer solstice) and for the southern hemisphere it is the shortest (the winter solstice).

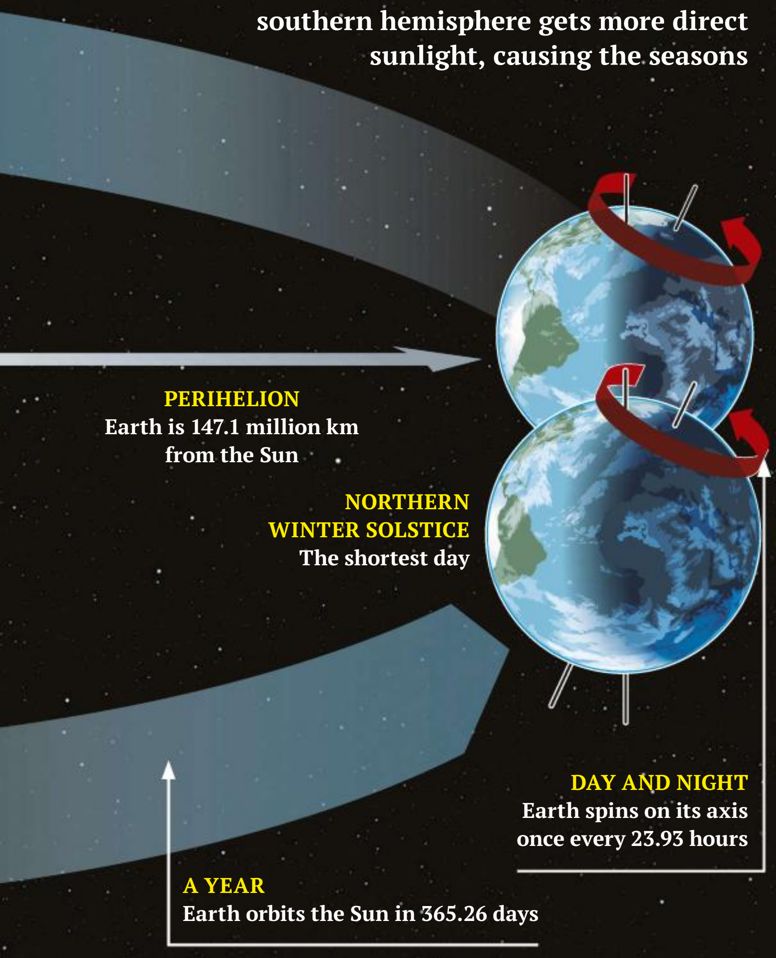
Six months later, the tilt is reversed so that the south pole points towards the Sun and the north pole leans away. This marks the shortest day in the northern hemisphere and the longest day in the southern hemisphere. As Earth goes round the Sun, its axis always tilts in the same direction in relation to the stars.

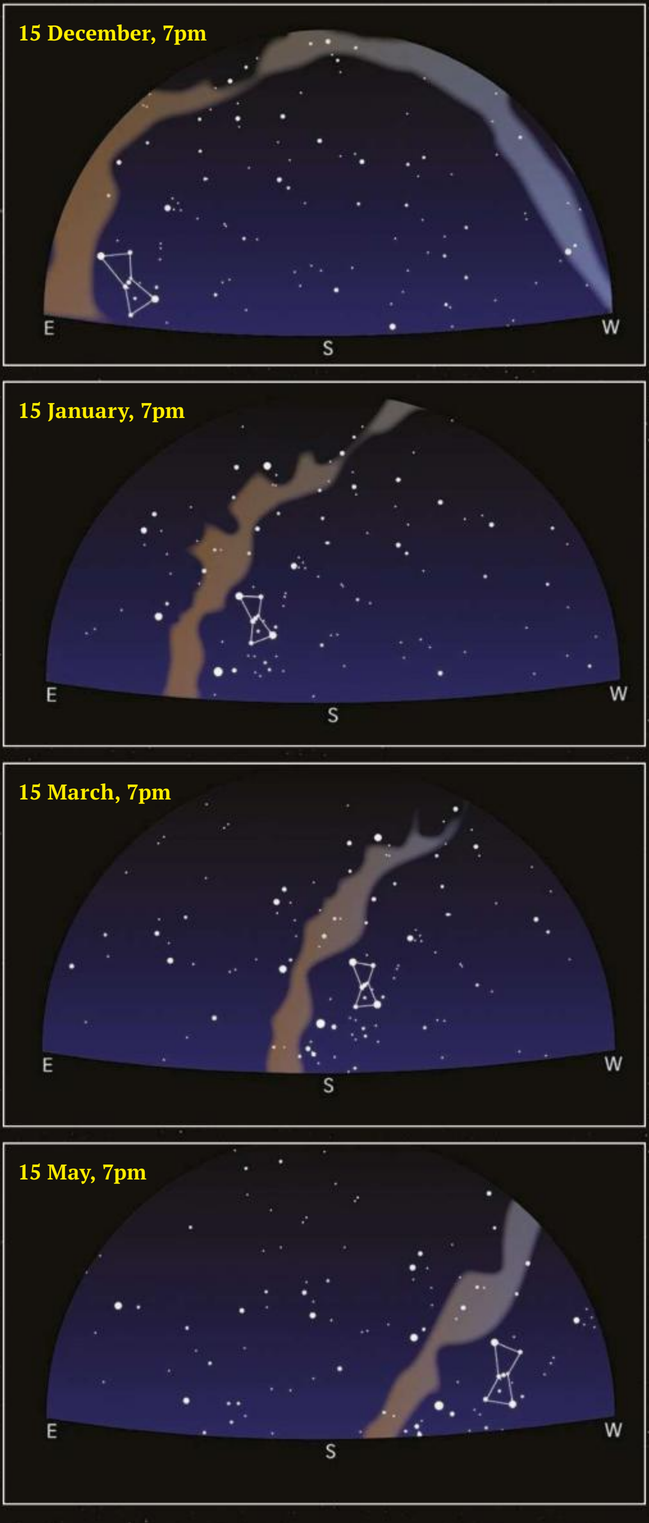
The Earth's motion doesn't just create the seasons. It also explains why our view of the constellations changes. Although the solar day lasts for 24 hours, Earth's rotation with respect to the stars is nearly four minutes shorter – it only takes 23 hours and 56 minutes for the stars to return to the same position that they were in the night before, a period known as the 'sidereal day'. The reason for this difference is that, from one day to the next, Earth completes 1/365th of its orbit around the Sun. So each night, if you look due east, you look out onto a slightly different part of space.

This time difference between the solar and sidereal days, although short, causes the stars to rise almost four minutes earlier each day. Over the weeks and months, this causes the constellations visible in the night sky to change. After 12 months, the stars cycle all the way back to the same positions they were in a year before.

EARTH'S JOURNEY AROUND THE SUN

As it orbits the Sun, Earth spins on a tilted axis. Either the northern or southern hemisphere gets more direct sunlight, causing the seasons


PERIHELION
Earth is 147.1 million km from the Sun
NORTHERN WINTER SOLSTICE
The shortest day
DAY AND NIGHT
Earth spins on its axis once every 23.93 hours
A YEAR
Earth orbits the Sun in 365.26 days



Earth's motion through space makes the stars rise four minutes earlier each evening; the long-term effect is that the constellations appear to move over the course of the year

EARTH ORBIT ILLUSTRATION BY ADRIAN DEAN, CHARTS BY PETE LAWRENCE

Stare hard enough at our nearest neighbour and you may see the Man in the Moon

THE MOON

Discover the phases of our planet’s only natural satellite

The cause of our ocean tides, subtle cycles in living things and the only other world that humankind has so far set foot upon, the Moon seems a familiar and tangible place. A quarter of Earth’s diameter and just a quarter of a million miles away, it’s 100 times closer than Venus.

Before telescopes were invented, observers noticed an unchanging pattern of darker patches that would later become known as maria, or ‘seas’, because they were assumed to be large stretches of water. They act as ‘moon-marks’ for different cultures – for example, the face of the ‘Man in the Moon’ as observed in the West is the ‘Rabbit pounding rice’ in East Asian folklore and the ‘Lady Reading a Book’ in the southern hemisphere’s night sky.

The reason we see the same lunar features staring back at us is because the Moon has got into a synchronous rotation with Earth. This means that it spins once on its axis in the same time it takes to complete an orbit of our planet – 27.3 days, or a ‘sidereal month’.

LUNAR LINGO

The illumination of the Moon’s Earth-facing hemisphere changes over the course of the month – a word that we get from ‘moon’. Although the Sun is always shining on a full half of the Moon, the proportion of the lit side we are able to see depends on where the Moon is in its orbit around Earth, giving rise to the phases we see.

Imagine you are looking down on the Earth, Moon and Sun from above. When the three line up with the Moon in the middle, the Moon’s lit half points away from us on Earth and we see a new Moon. Slowly emerging from its new phase into the evening sky, the lunar crescent thickens from one day to the next. The term ‘waxing’ is used to describe this thickening phase. The waxing crescent leads to the Moon appearing as an illuminated semicircle roughly a week after new. Next comes a convex phase called gibbous before full Moon, when our planet, satellite and star are aligned once again.

ISTOCK, ILLUSTRATION BY STEVE MARSH

After full Moon the phases reverse, and the illuminated part of the Moon begins to shrink or wane. The Moon becomes gibbous before reaching the three-quarter point of its orbit when it takes the appearance of a semicircle once again. After this, it takes approximately a week for the Moon to go through its waning crescent phases, visible in the early morning sky, before it becomes new again. It takes 29.5 days for the Moon to complete this cycle of phases, which are known as a 'lunation', slightly longer than it does to complete an Earth orbit – known as a 'synodic month'.

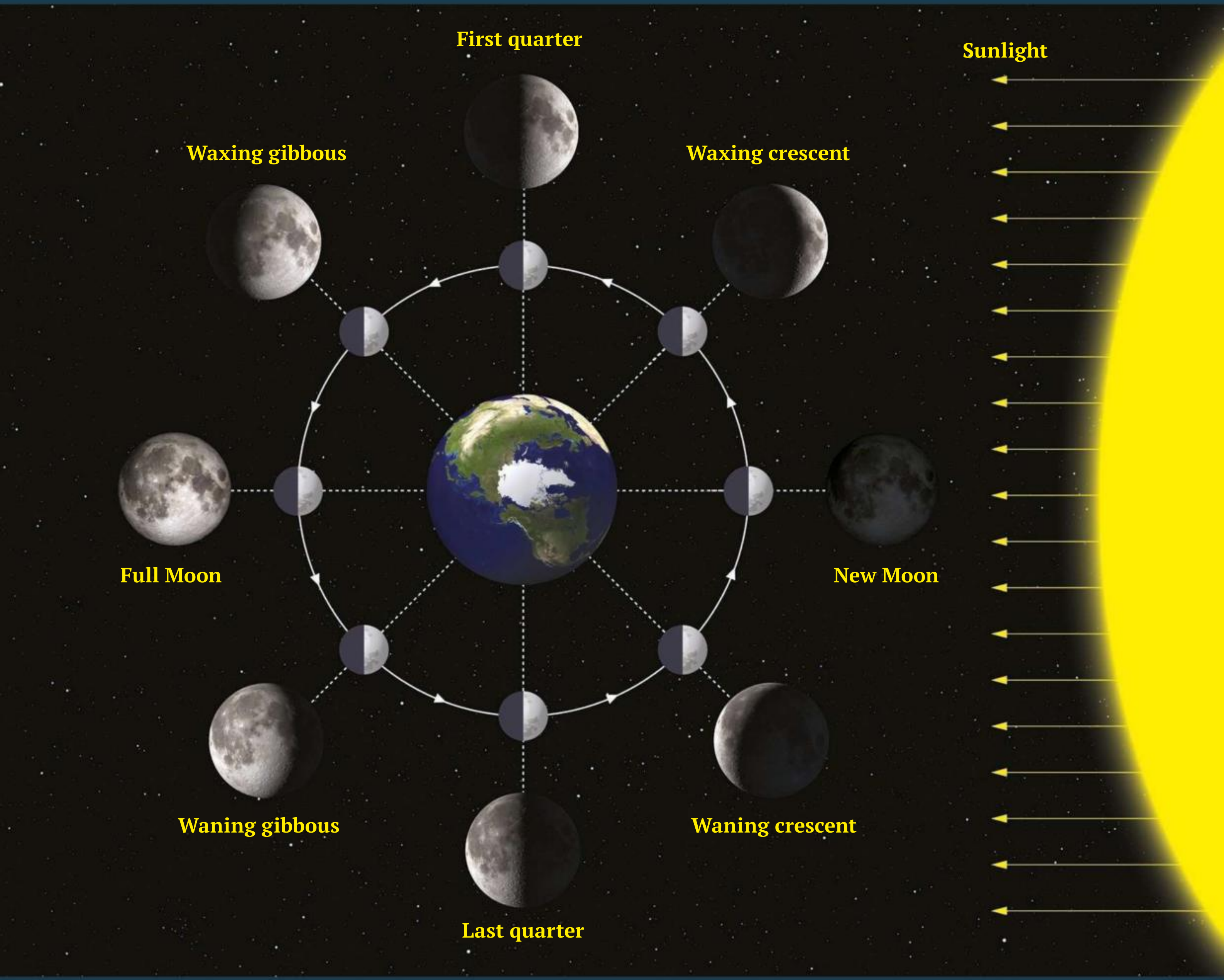
The nature of the Moon's orbit generates another effect that is a boon to lunar observers, a rocking and rolling motion that we call 'libration'. The Moon's orbit is elliptical, and as a result its distance from Earth doesn't remain constant. When closest it speeds up slightly; when more distant it slows down. This small variation is enough to cause the Moon to 'nod' back and forth on its axis, giving us an occasional chance to see a little more around its eastern and western edges.

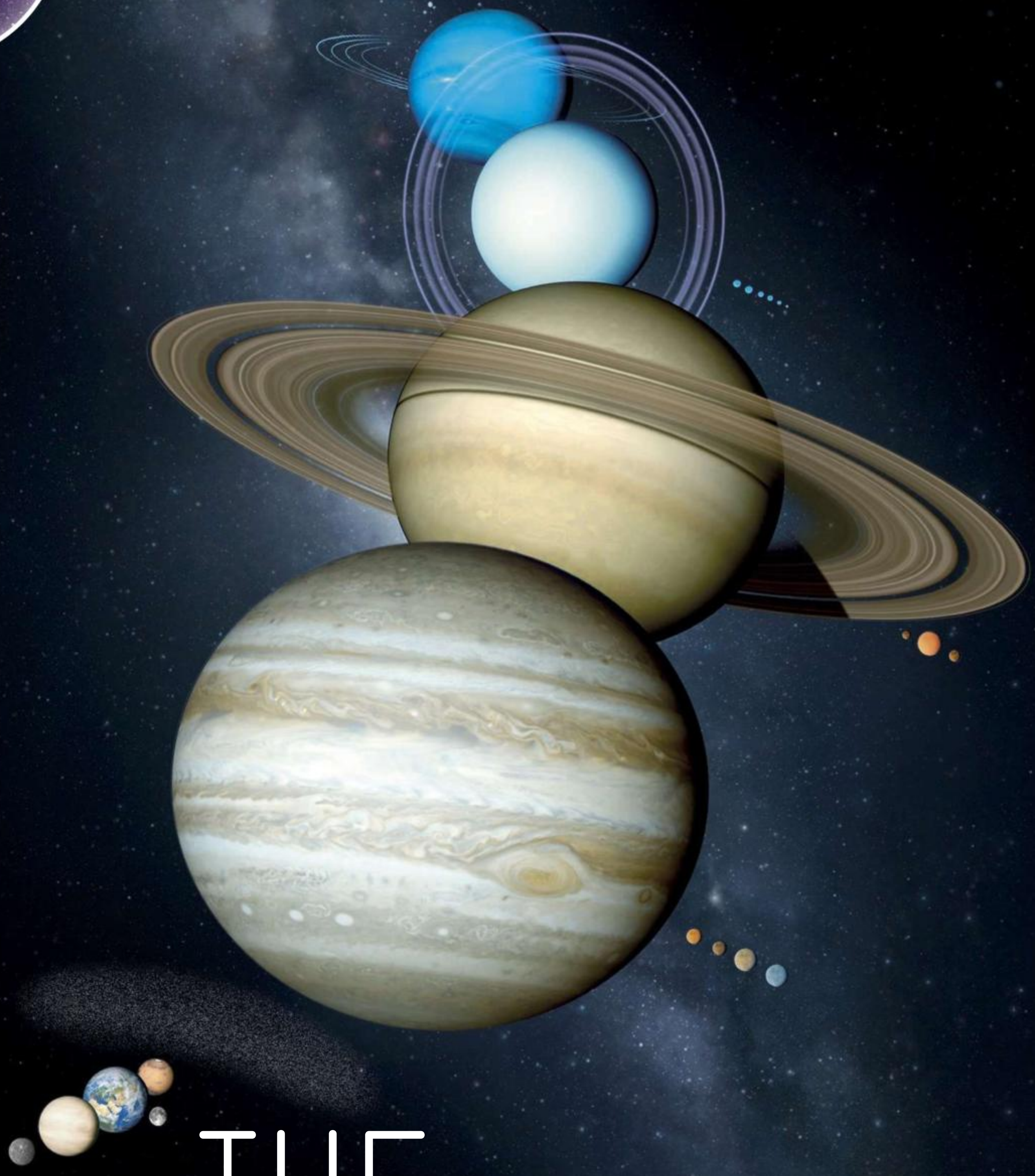
As the orbit is also slightly inclined, sometimes we get the chance to peek over the top, and under the bottom, of the Moon. Taken together, this libration allows us to see a total of 59 per cent of the Moon's globe, revealing tantalising features normally hidden from our view.

See page 74 for the Top 10 Moon sights

THE MOON'S PHASES

The Moon's appearance changes depending on where it is in relation to the Earth and Sun





THE PLANETS

Our closest neighbours are popular targets for astronomers

DETLEV VAN RAVENSWAAY/SCIENCE PHOTO LIBRARY, DUNCAN HALE-SUTTON/ALAMY STOCK PHOTO, PAUL WOOTTOM X 2

August 2006 was a sad moment in time for Pluto – that month it lost its planetary status, after other similar (and some larger) objects were found where it orbits. Our Solar System now has eight bodies recognised as planets and five as dwarf planets, including Pluto, Eris and Ceres.

To meet today's definition of a planet, as well as being rounded by its own gravity and in orbit around the Sun, a body has to have cleared its orbit of other objects its size, which Pluto hasn't done.

All the planets move in the same anticlockwise direction around the Sun, if we take Earth's north pole as an arbitrary reference of 'up'. The Sun's 'gravity well' is immense – imagine a great bowling ball creating a dip in a trampoline. The planets are like marbles rolling along inside this dip around the bowling ball Sun. The closer a planet is to the Sun, the stronger its pull of gravity and the faster it has to move to keep from being pulled into solar destruction.

All this speed, or lack of it, affects how a planet moves across the night sky as seen from Earth's surface. Whereas distant Saturn crawls around the sky, barely moving among the stars, Mercury's fast pace means it shifts considerably day by day. This is what the gravity of the Sun does, but there's also its light to consider. We only see the planets because the Sun lights them up. Their brightness is due to many things, including their actual distance from the Sun, the distance they are from your eye, and their size, composition and colour.

A conjunction of Venus (top left) and Mercury (below it, right), as seen from Edinburgh

MERCURY RISING

As Mercury and Venus are closer to the Sun than Earth, they are known as the 'inferior planets'. The best time to observe them is when they appear furthest from the Sun in the sky, a position astronomers call 'elongation'. At these times, the planets are only half lit by the Sun, but after this they swing back into the solar glare, where they become less visible. When Mercury and Venus are at eastern elongation, they set after the Sun in the evening; at western elongation they rise before the Sun in the morning. The Sun interferes with our views of the inferior planets twice during their orbits, when they all line up. These two points are known as 'inferior conjunction' and 'superior conjunction'.

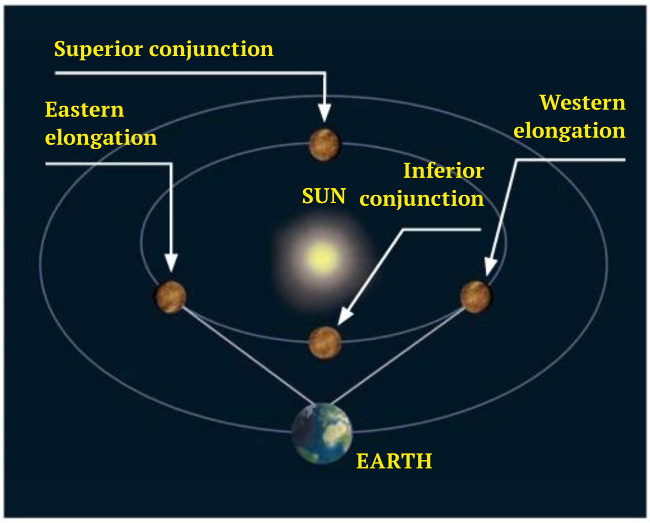
The planets further out from Earth are called superior planets. These don't present the same problems for observers as Mercury and Venus, and they can be visible all night long. When any of them line up with Earth on the far side of the Sun, they are said to be 'in conjunction'.

The best time to observe the superior planets is when they are close to Earth. This happens at 'opposition', when the planet is on the opposite side of the sky to the Sun and we are presented with a fully illuminated disc – visually it's close to or at its biggest and brightest.

PLANET SPOTTING

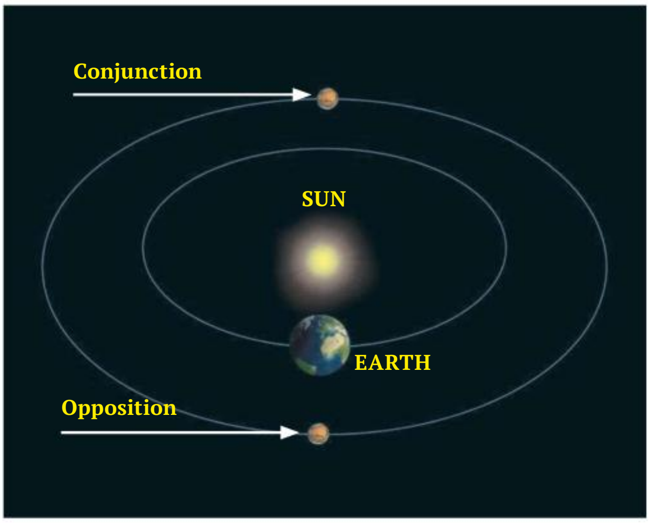
Discover the best times to observe the inferior and superior planets

INFERIOR PLANETS



The best time to observe inferior planets is at elongation

SUPERIOR PLANETS



The best time to observe superior planets is at opposition

THE INNER PLANETS

These worlds are mostly made up of metals or silicate rocks

MERCURY

Diameter: 4,880km · Moons: 0 · Distance from Sun: 58 million km

The closest planet to the Sun, Mercury is a place of extremes. It is the smallest and densest planet in the Solar System, barely larger than our Moon. It takes 59 Earth days to rotate once and 88 to orbit the Sun, meaning its parched surface experiences temperatures hot enough to melt lead on the sunward side, but is sub-Antarctic on the side in shadow.

This small world is a real challenge to observe for a variety of reasons. It's a fast mover, travelling around the Sun four times more quickly than Earth, so don't expect it to hang about in any part of the sky for very long. Mercury's orbit is a fairly eccentric oval shape, and it's on a bit of a tilt too, which means some times are better for viewing it than others: spring evenings and autumn mornings. If that's not tricky enough, you only have a relatively short observation window on any day you choose to look, as Mercury never strays very far from the Sun.

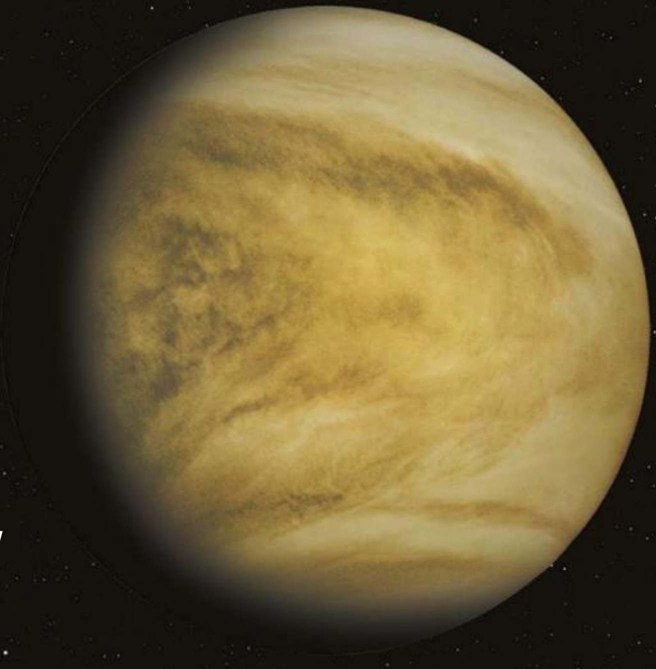
In spring, start looking 30 minutes after sunset, after which you'll have about another 45 minutes to see it. Autumn gives you a longer view, from about an hour and 45 minutes before sunrise, but that does mean getting up exceedingly early.

VENUS

Diameter: 12,100km · Moons: 0 · Distance from Sun: 108 million km

Venus is sometimes called 'Earth's evil twin'. It is similar in size and composition to our planet, but a dense carbon dioxide atmosphere and sulphuric acid clouds make its surface a hellish 470°C. The planet spins slowly, in the opposite direction to most planets, and takes about the same time to rotate on its axis (243 Earth days) as it does to travel around the Sun (225 days).

As Venus's orbit is slower than Mercury's, it can be visible for months on end, and sometimes for up to three hours after sunset or before sunrise. When Venus is at its brightest, it becomes the third brightest object in the sky, only beaten by the Moon and the Sun. This is caused by sunlight reflecting off its bright white carbon-dioxide clouds, and has led to Venus being called the 'Evening Star' or 'Morning Star' depending on when it appears. Venus can come very close to Earth, plus it's rather big, meaning that it's a good target for binoculars, through which you can easily see its larger phases.



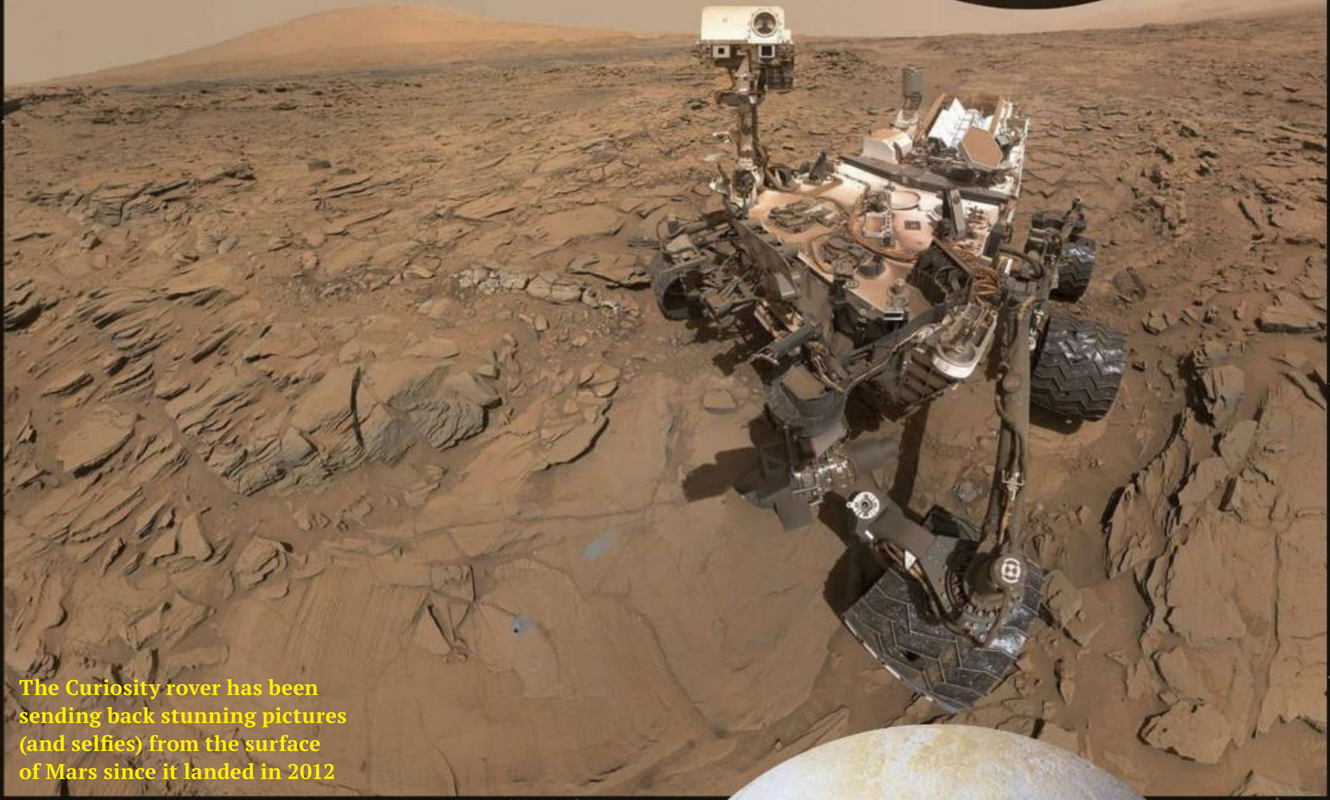
NASA/JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY/CARNEGIE INSTITUTION OF WASHINGTON, NASA/USGS, NASA/JPL-CALTECH/MSSS, NASA/JPL-CALTECH/UCLA/MPS/DLR/IDA, NASA/ JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY/SOUTHWEST RESEARCH INSTITUTE

MARS

Diameter: 6,800km · Moons: 2 · Distance from Sun: 228 million km

The Red Planet is the most visited extraterrestrial destination in the Solar System. Dozens of missions have ventured there, and they have explored the Martian landscape in incredible detail. Smaller than Earth but with the same land area, Mars is like a cold, rocky desert, littered with canyons and volcanoes. The planet has polar caps and a thin atmosphere of mostly carbon dioxide. Although dry today, Mars's mineral salts and rock formations suggest that it was wet in the past, and could possibly have harboured life.

Mars differs from Mercury and Venus in that its position in the Solar System – on the other side of Earth – means it can be 'up' from sunset until sunrise. A small telescope can reveal lighter, pale-reddish areas, darker patches and the bright white of the ice caps.



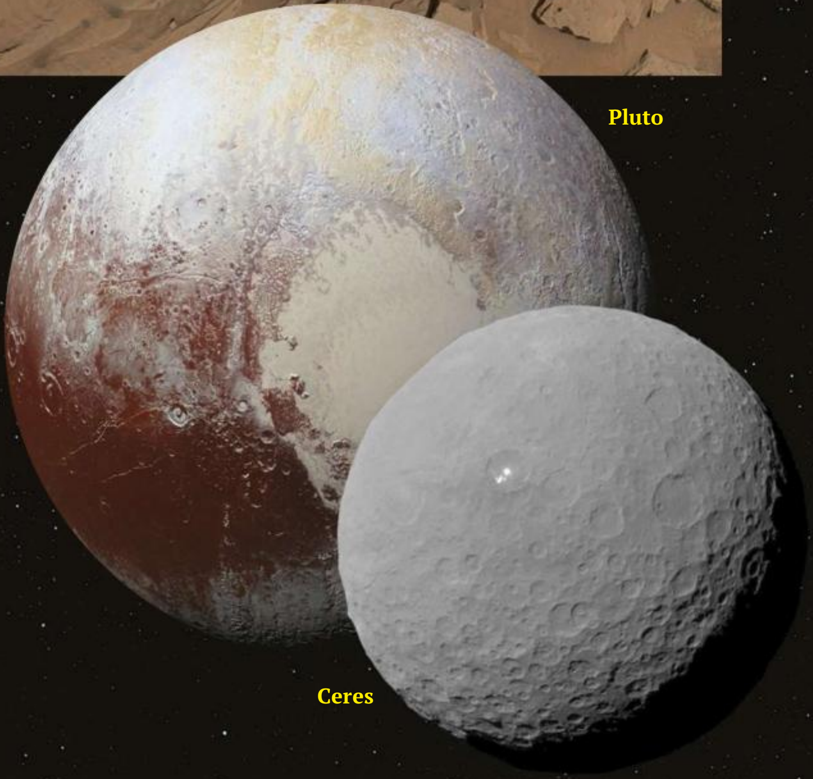
The Curiosity rover has been sending back stunning pictures (and selfies) from the surface of Mars since it landed in 2012

THE DWARF PLANETS

Diameter range: 975km to 2,330km

A dwarf planet is, according to the International Astronomical Union, a body that orbits the Sun and is not a satellite, spherical in shape due to its own gravity and too small to have cleared its orbit of debris and so claim the title of a fully fledged planet. This classification was agreed after the 2005 discovery of Eris, an icy body in the outer Solar System very similar to Pluto, which was then considered a planet. In the fierce debate that followed Pluto was demoted into the newly created class, which also contains outer Solar System bodies Haumea and Makemake, and Ceres in the Asteroid Belt.

Ceres is the largest, but still comparatively small, so you will need binoculars to find it. Pluto is best seen by taking images of the region of sky it is in over consecutive nights and looking for the faint moving dot.



Pluto

Ceres

THE OUTER GAS GIANTS

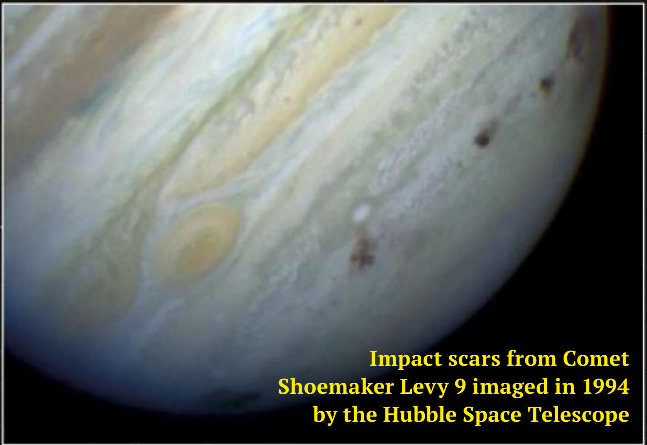
These distant worlds include the Solar System's largest

ISTOCK X 2, HUBBLE SPACE TELESCOPE COMET TEAM AND NASA, NASA/JPL/SPACE SCIENCE INSTITUTE, NASA/JPL/STSCI, MICHAEL KARRER/CCDGUIDE.COM, NASA/JPL

JUPITER

Diameter: 143,000km • Moons: 67
Distance from Sun: 778 million km

The largest planet in the Solar System, Jupiter has more mass than all of the other planets put together and is second only to the Sun in terms of gravitational power. In 1994 it enticed comet Shoemaker-Levy 9 to fragment and crash into its swirling clouds – other likely comet crashes were recorded in 2009, 2010 and 2016. Jupiter is mostly gas, its composition of hydrogen and helium similar to that of the Sun.



Impact scars from Comet Shoemaker Levy 9 imaged in 1994 by the Hubble Space Telescope

Jupiter's four Galilean satellites are clearly visible through binoculars

With a good pair of binoculars the first things you'll notice are its four most famous moons: Io, Europa, Ganymede and Callisto, spied by Galileo Galilei in 1610. With a telescope you'll see a slightly squashed sphere. This is due to its fast spinning 'day' of just under 10 hours, which causes the equator to bulge outwards and the poles to flatten. Jupiter's cloudy atmosphere is revealed as dark bands separated by white zones. The longer you look, the more features appear, so keep an eye out for spots, wisps and kinks. The most famous feature is the Great Red Spot; twice the width of Earth, this is a gigantic storm with winds reaching up to 644km/h.

SATURN

Diameter: 120,500km · Moons: 62
Distance from Sun: 1.43 billion km

Saturn is known for its spectacular rings, made from millions of chunks of water-ice spread out into a thin disc only a few tens of metres thick but stretching 100,000km from the planet's surface. The rings form bands, some broad, some narrow. Scores of moons orbit within the rings, some carving out wide gaps. As with Jupiter, a handful of them are visible to observers.

Saturn's brightness varies due to the way the rings are tilted and how much sunlight they reflect. The planet is not so bright when the rings are edge-on to us, but its brightness increases over 7.5 years as the rings open up to observers on Earth. Then it fades again over the same period. If you're wondering why this takes 7.5 years, it's a quarter of the time that Saturn takes to go around the Sun.

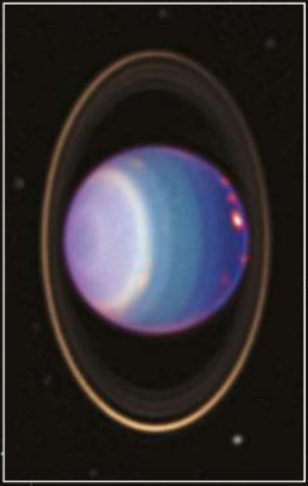
The best way of understanding Saturn's tilting effect is to go out and look at the planet – it really is one of the telescopic marvels of the Solar System. It doesn't matter if you have a small scope – the sight of this tiny, ringed world hanging in a large, inky black field of view is magical. The view of larger scopes will start to show detail in the rings and on the planet itself.

URANUS

Diameter: 51,000km · Moons: 27
Distance from Sun: 2.87 billion km

The first planet to be discovered with a telescope, found by William Herschel in 1781. Its blue-green hue comes from the abundance of methane ices in its hydrogen and helium atmosphere, which also contains water and ammonia ices. Like Venus, Uranus spins from east to west, but its axis of rotation is tilted almost 90° from the plane of its orbit, suggesting that it might have been knocked over by a collision. Five rings were discovered in 1977 – in 1986 the Voyager spacecraft identified a further six, and two more were found by the Hubble Space Telescope in 2005, bringing the total to 13.

Visually, Uranus doesn't have much going for it, whether you use your eyes, a pair of binoculars or a telescope. By simply turning your head upwards, you can just about see this gaseous world as a very faint star at the limits of visibility (around mag. +5.6). You won't see much from anywhere with light pollution, however – the sky has to be very black. The view improves a little through a telescope, showing a greenish speck.



▲ The rings around Uranus imaged by the Hubble Space telescope in 1998

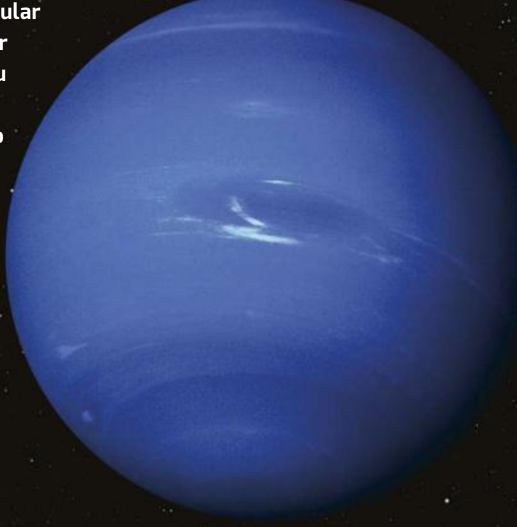
▲ Through a telescope Uranus looks like a tiny blue-green disc

NEPTUNE

Diameter: 49,500km · Moons: 13
Distance from Sun: 4.5 billion km

Neptune's composition is similar to that of Uranus, being mainly hydrogen and helium with methane ices, water ices and ammonia ices mixed in. But unlike featureless Uranus, Neptune is wracked by stormy weather, with giant tempests boiling among the clouds. Its winds are the fastest in the Solar System, reaching an incredible 600m/s (that's 2,200 km/h). Neptune has six known rings. They appear to have bright clumps within them, which may be short-lived collections of debris.

At around mag. +8.0 you need at least binoculars to see Neptune. When looked at through a telescope it looks like a 'star' with a hint of blue, but it is not as spectacular as its larger, closer compatriots. If you have a very large scope you can also catch a glimpse of Neptune's largest moon, Triton, which is mag. +13.5.



Comet C/2013 US10 (Catalina) photographed on 1 October 2015

ICY WANDERERS

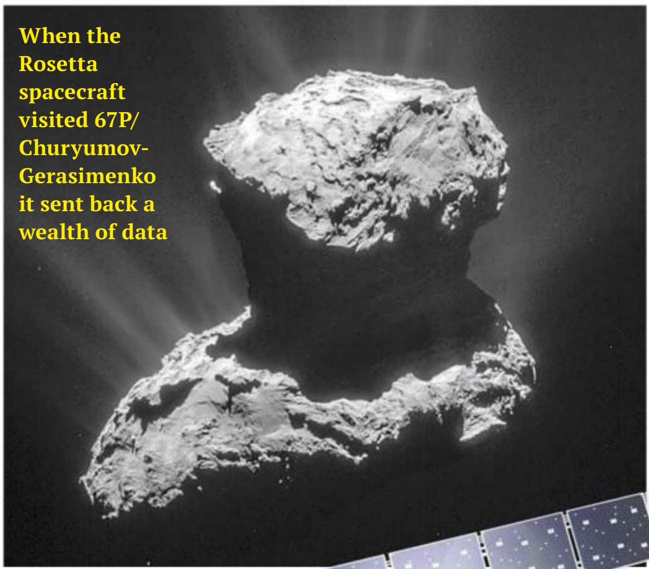
Spectacular comets may be visible only once in a lifetime

ISTOCK X 2, ESA/ATG MEDIALAB, ILLUSTRATION BY PAUL WOOTTON, ESA/ROSETTA/NAVCAM X 2, LOWELL OBSERVATORY, NASA, JAMES W. YOUNG (TMO/JPL/NASA)

Wandering through the Solar System, comets can be among the most incredible of astronomical sights and, after years of careful observation, astronomers have coaxed out the secrets hidden within their glow.

The heart of a comet is its nucleus, a core of ice laced with rock and dust, a few kilometres wide. Though sometimes called a 'dirty snowball', the ice found on comets is far more exotic than that on Earth.

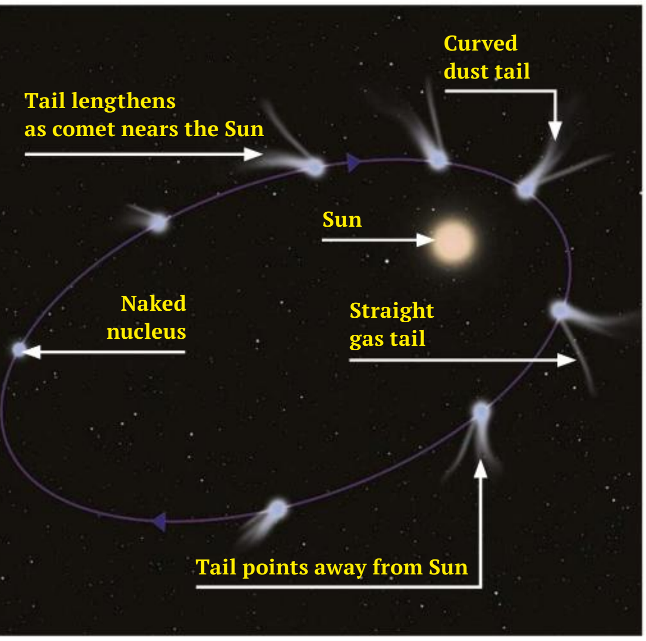
When the Rosetta spacecraft reached the comet 67P/Churyumov-Gerasimenko in 2014 it performed the first in-situ analysis of the comet's nucleus, finding not only water ice, but also carbon dioxide and monoxide, as well as traces of ammonia, methane and methanol. These highly volatile compounds are usually found as a gas or



When the Rosetta spacecraft visited 67P/Churyumov-Gerasimenko it sent back a wealth of data

CHASING THE TAIL

The most alluring part of a comet is surely its huge tail, but it's not always obvious that there are two. The most apparent is the dust tail, swept out in an arc by the solar wind. However, the magnetic field captures the gas, forming a fainter second tail. Sometimes the comet's position relative to Earth means the tails appear to go in two different directions.


Curved dust tail
Tail lengthens as comet nears the Sun
Sun
Naked nucleus
Straight gas tail
Tail points away from Sun

liquid on Earth, but the frigid depths of space have frozen them to ice as hard as rock.

These snowballs travel in huge elliptical orbits, briefly visiting the inner Solar System at one end before travelling billions of kilometres to the outer regions. 'Long-period comets' travel into deep space, taking thousands of years to complete an orbit, while 'short-period comets' have orbits that take only a few years or decades. Halley's Comet is visible to the naked eye from Earth every 75.3 years.

COMAS & TAILS

It's thought short-period comets come from the Kuiper Belt, after being knocked out of orbit. Beyond the Kuiper Belt, the Oort Cloud stretches to 3.2 lightyears from the Sun. If a passing star kicks one of its bodies off course, it creates a long-period comet.

For most of these orbits, the nucleus remains an inert lump of ice, but this changes as the comet nears 'perihelion' – its closest approach to the Sun. When close enough, the solar radiation heats the surface, causing the volatile components to boil. As the gas escapes into deep space it lifts off dust, creating a shroud that can stretch out over 50,000km around it – the coma.

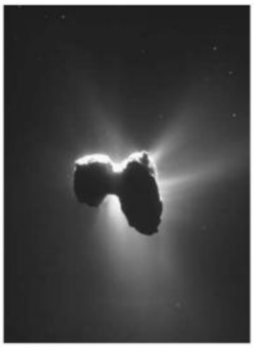
As the comet gets closer to the Sun, this envelope begins to feel the solar influence even more acutely, as its wind and magnetic field sweep the dust and gas out into a huge tail, which can extend for millions of kilometres. Some of the tail's debris is left behind in its orbit, forming a meteoroid stream. Several of these cross the Earth's orbit, and when we pass through them every year, we see the debris burning up in the atmosphere as a meteor shower.

Sunlight reflecting off the coma and tail causes these celestial visitors to glow in the night, making them an ever-popular target for astronomers. But, only a handful of comets can be seen every year with the aid of a small telescope. Websites such as **www.icq.eps.harvard.edu/cometobs.html** or **www.ast.cam.ac.uk/~jds** will tell you which comets are active and where to find them.

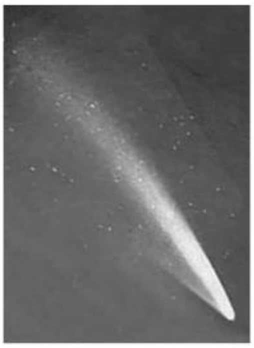
FAMOUS COMETS

Dominating the sky or the landing site for a probe, these are the best-known comets

HALE-BOPP
Closest approach: 136 million km
Orbit: 2,520-2,533 years
Famed for: Visible to the naked eye for a record 18 months in 1996/97, Hale-Bopp will return around the year 4385.



67P/CHURYUMOV-GERASIMENKO
Closest approach: 186 million km
Orbit: 6.4 years
Famed for: Target of the Rosetta mission, which sent the Philae lander to its surface, finding water and organic compounds.



GREAT DAYLIGHT COMET
Closest approach: 19 million km
Orbit: 57,300 years
Famed for: Spotted in January 1910, this comet quickly brightened until it outshone even Venus. Its tail was noticeably curved.

HALLEY'S COMET
Closest approach: 88 million km
Orbit: 75.3 years
Famed for: The only known short-period comet routinely visible to the naked eye, this regular visitor was observed as early as 240 BC.

IKEYA-SEKI
Closest approach: 450,000 km
Orbit: 876.7 years
Famed for: Its 1965 close pass of the sun made Ikeya-Seki one of the brightest comets in 1,000 years. It's thought to be a fragment of the Great Comet of 1106.

The Perseids are an annual meteor shower, caused by the Earth plowing through debris from comet Swift-Tuttle

SHOOTING STARS

Spotting a meteor streaking across the sky is a truly captivating sight to behold

ISTOCK X 4, ILLUSTRATION BY PAUL WOOTTON

You may know of meteors as 'shooting stars', but the truth is there is nothing stellar about them. The dramatic, bright trails that streak across the sky come from a much more harmless source – a dust particle the size of a grain of sand colliding with Earth's atmosphere, making it glow.

You will see several random, or 'sporadic', meteors an hour on any clear night, but a better way to catch them is during one of the annual meteor showers. These occur when Earth passes through the debris trail of a long-gone comet – a path of dust waiting to burn up in our planet's atmosphere.

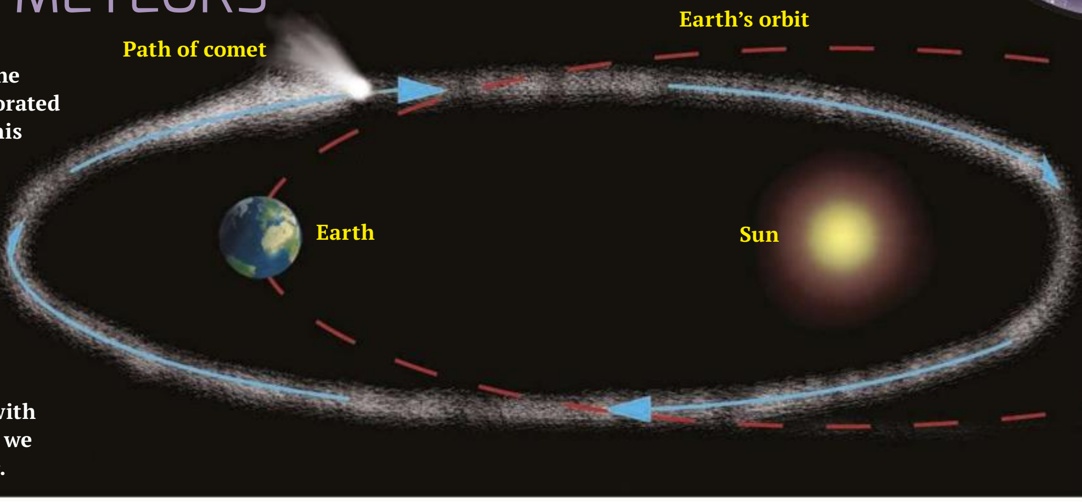
Meteor showers are named after the constellation they appear to come from – and, sometimes, the closest star. Most major showers will be active over a period of at least a few days – and some for a few weeks. But they have what's known as a 'peak' – the night when you can expect to see the greatest number of meteors. The rates can vary quite a lot, but prominent displays, such as the Perseids, can produce an average of one meteor a minute under clear, moonless skies at their peak. There is also the chance a particularly dense patch of dust could lie along the path of debris, creating a surge in meteor numbers.

HOW TO VIEW

The best time to observe is shortly after midnight on the date when peak activity is predicted, when the sky is

MAKING METEORS

By the time a comet approaches Earth, the Sun's heat has evaporated ice in its nucleus. This releases dust that follows the comet and, over time, can be spread out along all of the comet's orbit. When Earth intercepts this dusty path, lots of particles collide with the atmosphere and we see a meteor shower.



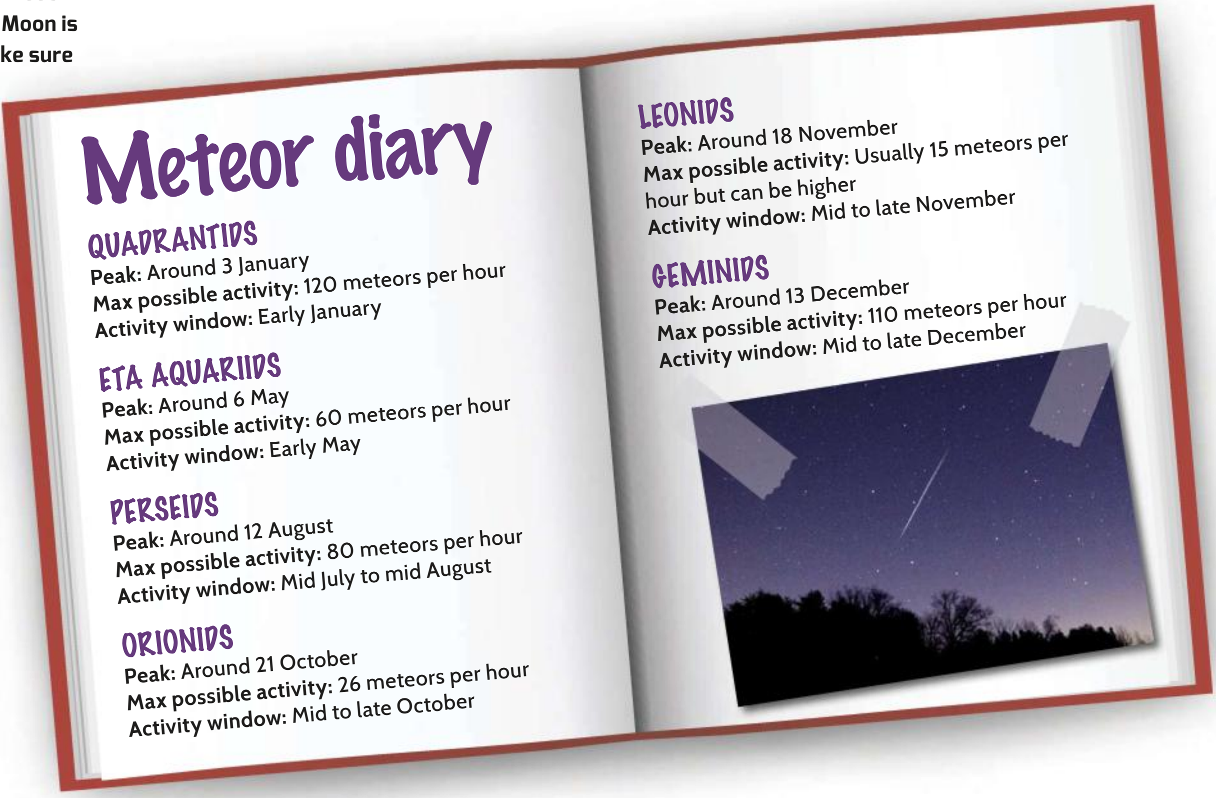
darkest and Earth's rotation faces the direction of the planet's motion in space, so the oncoming meteors seem to travel even faster.

As with any other form of observing, the best place to view is away from light pollution, so find as remote a location as possible and give your eyes at least 20 minutes to get really used to the darkness.

Don't look directly at the constellation that the meteor tracks appear to come from, concentrate your gaze high in the direction of the darkest portion of the sky that's free from obscuring trees and buildings. If the Moon is in the sky, try to make sure it's not in your field of vision or reflecting off walls or windows, as this will seriously degrade your night vision.

If you need to look at star charts or books to find your bearings, use a dim red light rather than a white one so that you don't lose your night vision. If you use a smartphone app, place a red cellophane filter over the screen.

Meteor trails often have tapered ends – this is one way you can tell them apart from a satellite



Meteor diary

QUADRANTIDS
Peak: Around 3 January
Max possible activity: 120 meteors per hour
Activity window: Early January

ETA AQUARIIDS
Peak: Around 6 May
Max possible activity: 60 meteors per hour
Activity window: Early May

PERSEIDS
Peak: Around 12 August
Max possible activity: 80 meteors per hour
Activity window: Mid July to mid August

ORIONIDS
Peak: Around 21 October
Max possible activity: 26 meteors per hour
Activity window: Mid to late October

LEONIDS
Peak: Around 18 November
Max possible activity: Usually 15 meteors per hour but can be higher
Activity window: Mid to late November

GEMINIDS
Peak: Around 13 December
Max possible activity: 110 meteors per hour
Activity window: Mid to late December

GLOWING AURORA

Magical aurorae show Earth's connection to the Sun and the wider solar system

These glowing curtains of lights, shimmering across the night sky, have captivated our imaginations for millennia. Aurorae are caused by charged particles streaming out of the Sun and interacting with Earth's magnetic field – our planet's protective shield – which channels them down towards the magnetic poles. As the particles reach lower altitudes, usually between 80km and 200km, they hit and excite the gases in Earth's atmosphere, causing a distinctive and colourful glow. This is far above the height passenger aircraft typically fly (around 10km), but the International Space Station and other manned spacecraft have flown through the upper reaches of an energetic display.

The colours depend on the brightness of the aurora. Faint displays will appear monochrome, with shades of grey. But most commonly the aurora has a green colour – light given off by oxygen in our atmosphere. Red can also be present, especially in the upper rays, as this colour comes from oxygen higher in our atmosphere, while blues and purples can appear in very bright displays when nitrogen becomes excited.

SEE THE LIGHT

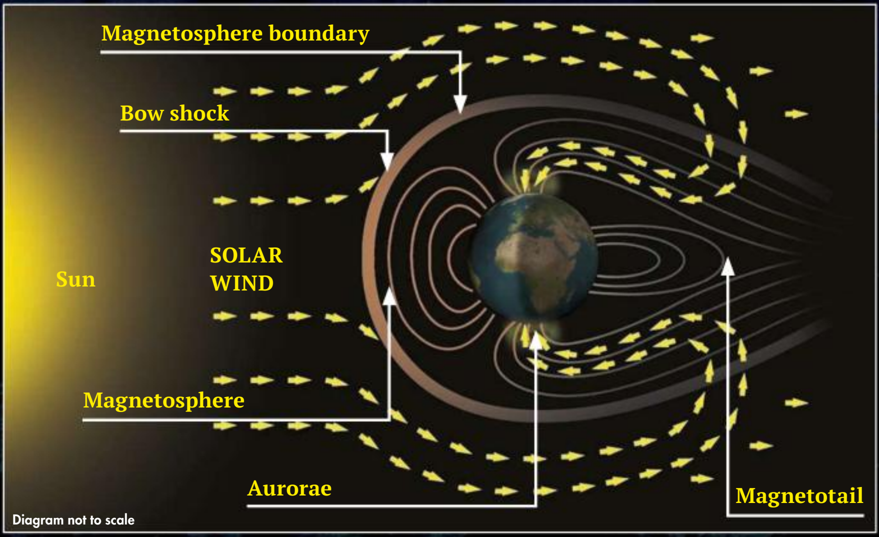
While some more energetic displays have been seen in the UK, your best chance to see an aurora is around the magnetic poles (which are about 11° away from the geographical poles – those traditionally referred to as the North and South Poles). In the Arctic Circle the phenomenon is known as the 'aurora borealis', or Northern Lights, and in the Antarctic it is the 'aurora australis', or Southern Lights.

So head as far north or south as you can. Once there, check space weather sites such as **aurorawatch.lancs.ac.uk** and **spaceweather.com** for aurora alerts, and position yourself with a clear view of the horizon (no need for a telescope or binoculars). Then all that remains is for the local weather to stay clear.

ISTOCK X 2, ILLUSTRATIONS BY PAUL WOOTTON, THINKSTOCK X 7

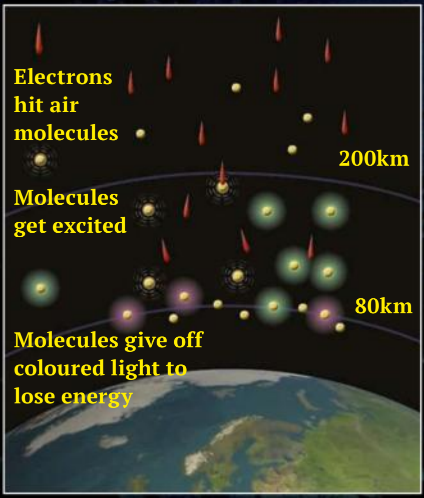
WHEN EARTH MEETS THE SUN

The area that Earth's magnetic field influences in space is called the magnetosphere. It protects life on our planet from radiation that would otherwise penetrate the atmosphere. The Sun releases vast amounts of charged particles called the solar wind that fly through space. Being so close, we rely on our magnetic field to deflect these particles. The shape of the magnetosphere is a result of how the magnetic influences of the Earth and Sun interact. On the Sun side it is pushed towards Earth; the boundary is known as the bow shock. On Earth's far side it trails a wake; this is called the magnetotail. When the solar wind is strong, Earth's magnetic field gets overloaded, and the extra particles cascade down into the atmosphere towards the poles, creating the aurorae.



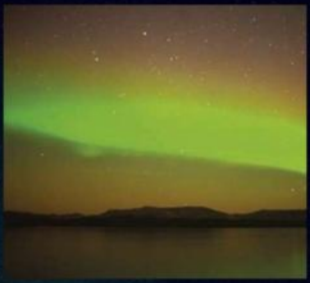
Charged particles from the Sun are channelled to the poles by Earth's magnetosphere

WHAT CAUSES THE AURORA?

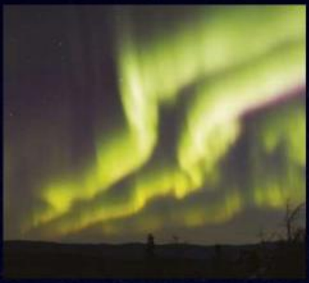

Electrons hit air molecules
200km
Molecules get excited
80km
Molecules give off coloured light to lose energy

Electrons hit atmospheric particles

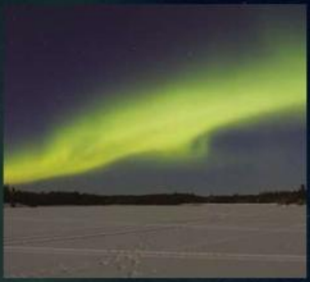
AURORAL STRUCTURES



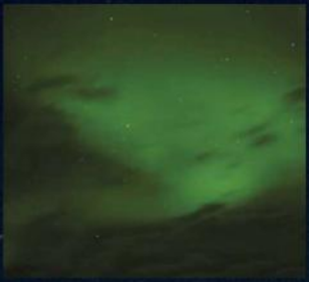
ARCS
An auroral arc: a general glow across the sky with a well-defined lower edge



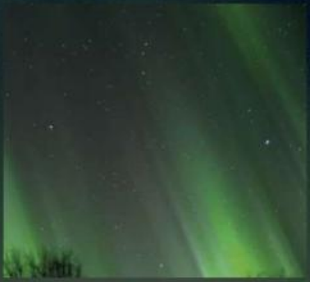
CURTAINS
A curtain aurora: a band of light that shows kinks and folds along its length



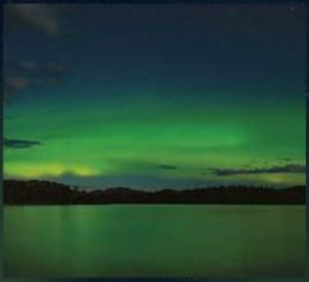
BANDS
An auroral band: similar to an arc but with an irregular lower edge



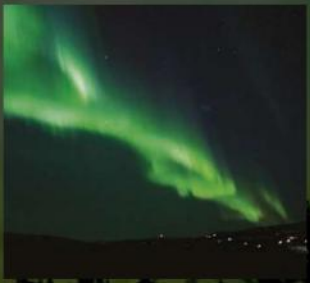
PATCHES
A patch aurora: these appear as a glow that has no particular shape



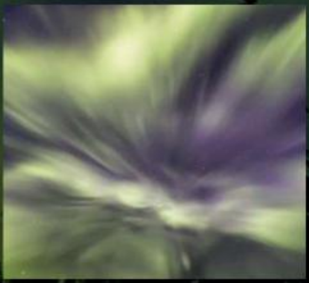
RAYS
Ray aurora: these present themselves as shafts of light stretching up into the sky



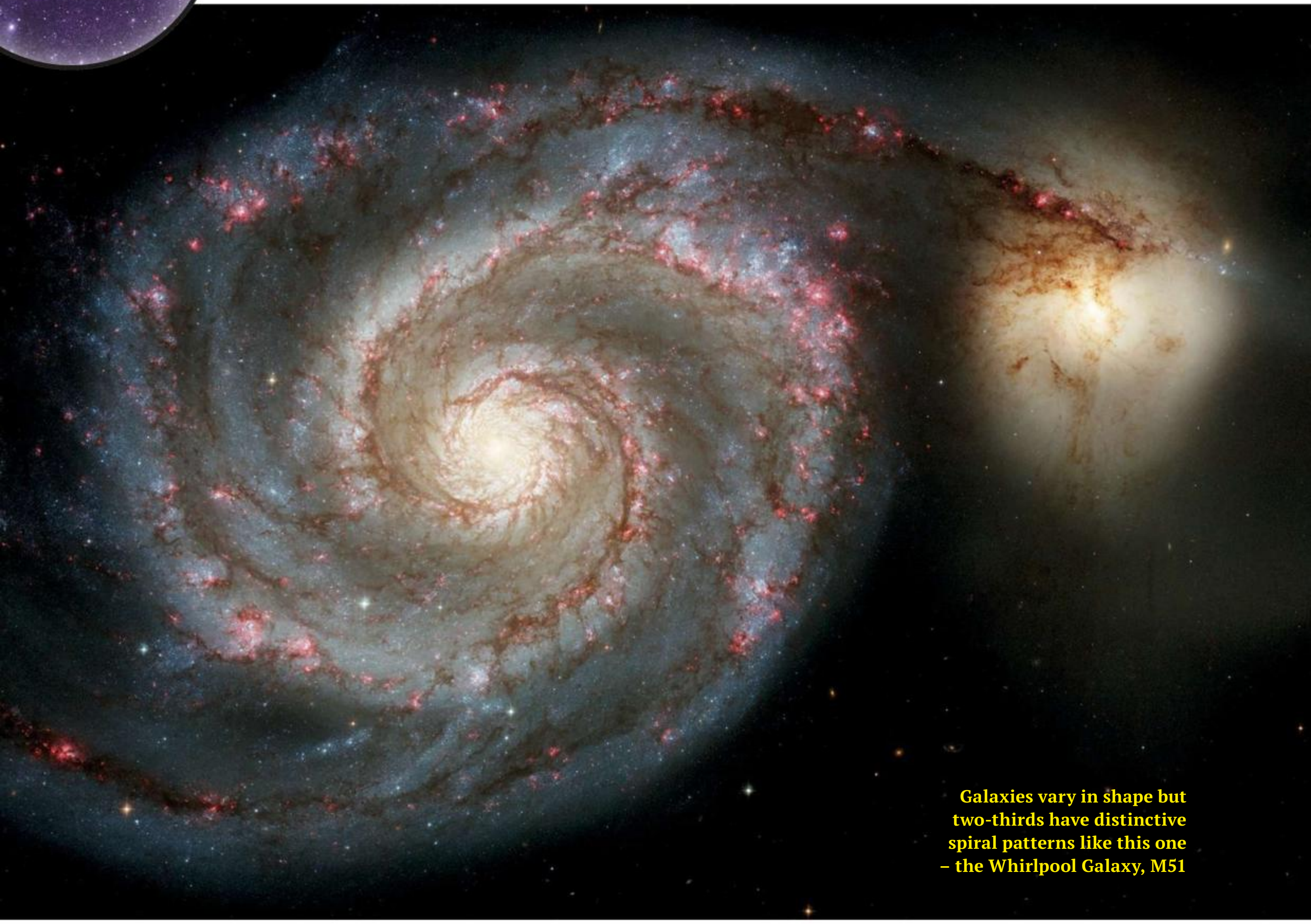
VEILS
An auroral veil: a general glow covering the sky with little structure to it



RAYED BANDS & ARCS
Rayed bands and arcs: similar structure to bands or arcs, also containing rays



CORONAE
A corona: rays that appear to converge at a point directly overhead



Galaxies vary in shape but two-thirds have distinctive spiral patterns like this one – the Whirlpool Galaxy, M51

THE DEEP SKY

Beyond our cosmic backyard, lie billions of galaxies, star clusters and glowing nebulae

GALAXIES

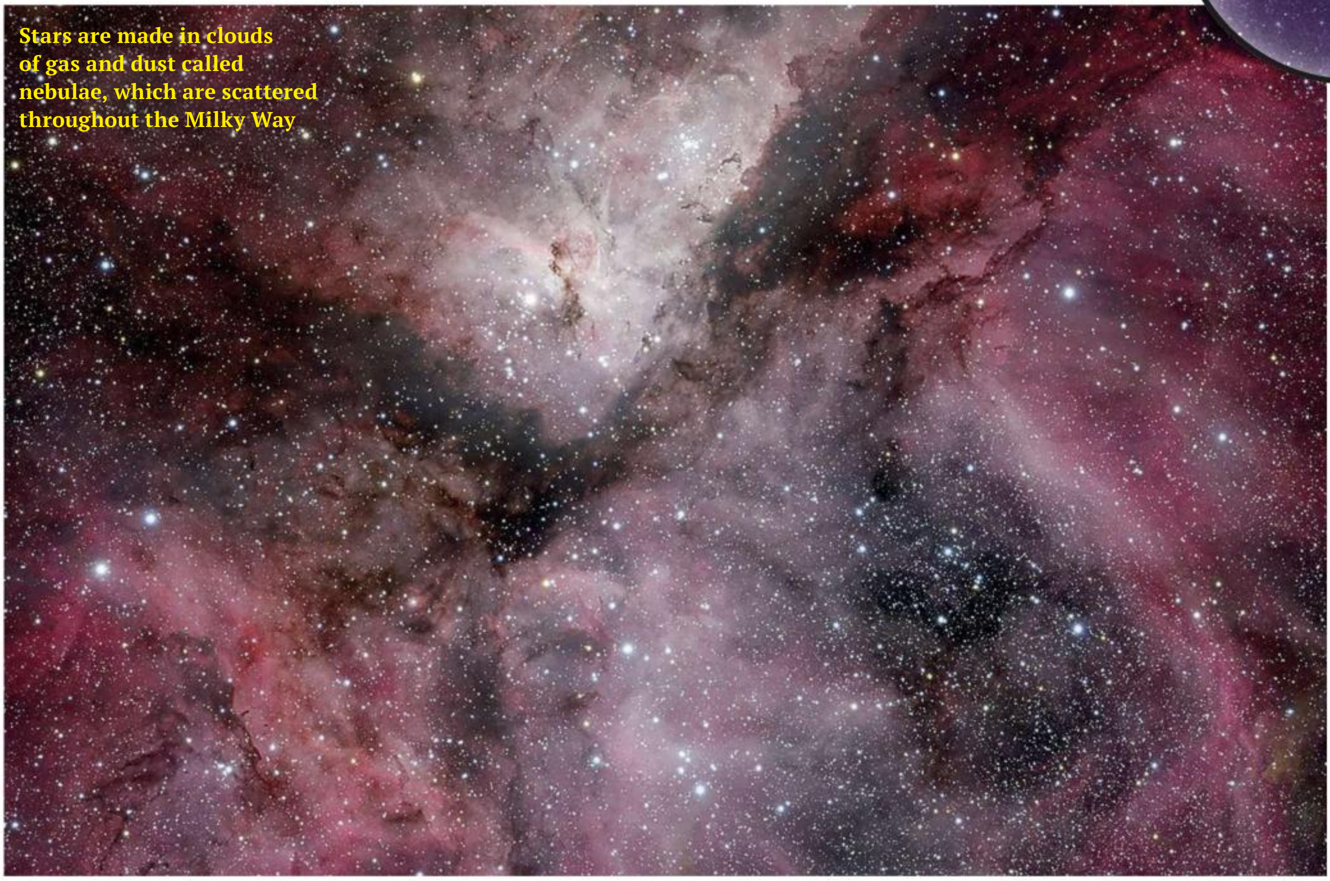
These concentrations of millions or billions of stars are gravitationally bound together along with gas clouds and pockets of dust. There are probably over 100 billion of them in the Universe. Some of the largest nearby galaxies appear in the night sky as faint smudges of light, but it was only in the early 20th century that astronomer Edwin Hubble proved that they actually exist well beyond our Galaxy – the Milky Way. Before then, they were thought to be spiral-shaped nebulae on its outskirts.

Hubble also established that galaxies vary in shape and size. Two-thirds have distinctive spiral patterns, while the rest range from neat ellipticals to irregular blobs. They can be dwarves containing millions of stars or giants harbouring trillions.

Astronomers are still piecing together why this is the case, but collisions and mergers seem to be important in determining how a galaxy evolves. Central black holes also seem to govern how gas is consumed and when stars are formed within these cosmic conurbations.

Galaxies are much more massive than they look. Around 90 per cent of their mass is not in luminous stars and gas, but in unseen 'dark matter'. It's arranged in a spherical halo, which governs the motions of the stars within. This invisible cocoon explains why the outskirts

ISTOCK X 2, GERALD RHEMANN/CCDGUIDE.COM



Stars are made in clouds of gas and dust called nebulae, which are scattered throughout the Milky Way

of spiral galaxies spin faster than if they were influenced by the quantity of stars and gas alone. Dark matter also governs how galaxies clump together under gravity to form filaments and clusters. Yet dark matter remains an enigma and astronomers are still trying to work out exactly what it is.

NEBULAE

These clouds of gas and dust are scattered throughout the Milky Way, mainly in the galactic disc. Nebulae are where stars are created. One idea of how it all starts is that a shockwave from a nearby supernova explosion compresses the cloud. Once the density of the gas passes a critical point, gravity takes over.

Gravity causes clumps of the nebula to pull together. The pressure at the centres of the clumps builds and the temperature rises dramatically. If there is enough gas to fuel the process, the region can become a protostar, an early stage in the making of a star.

If the temperature in the clump reaches 10 million degrees Celsius, the nuclear furnace that powers stars ignites. Over tens of millions of years it settles into normal life and joins what's called the main sequence, like our Sun.

STAR CLUSTERS

When you gaze up at the night sky, it looks like a lot of stars are on their own. But a solitary-looking star may be a member of a vast group that's travelling through space as a unit. If we wind the clock back millions of years, we might find these stars forming in the same vast cloud of dust and gas.

Known as open clusters, these families of anywhere from a few dozen to a few thousand stars are created in the dusty spiral arms of the Milky Way. They travel together through space, but gentle tidal forces eventually cause the stars to move apart until they begin to merge into the general starry background.

There is another variety of star cluster out there: the globular cluster. These are much bigger than the open sort, consisting of hundreds of thousands or millions of generally reddish, older stars. Whereas open clusters are found and made within the plane of the Milky Way, globular clusters form a halo around it and their creation is less well understood.

⮝ Globular clusters contain thousands of reddish, older stars

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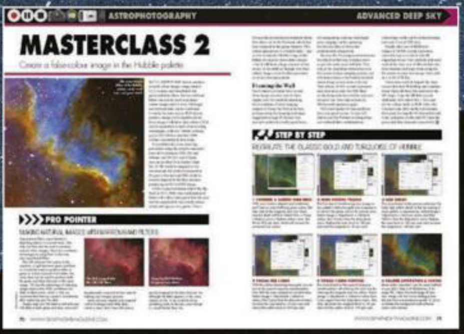

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START STARGAZING

The lowdown on what equipment you need and how to get started on your astronomical adventure

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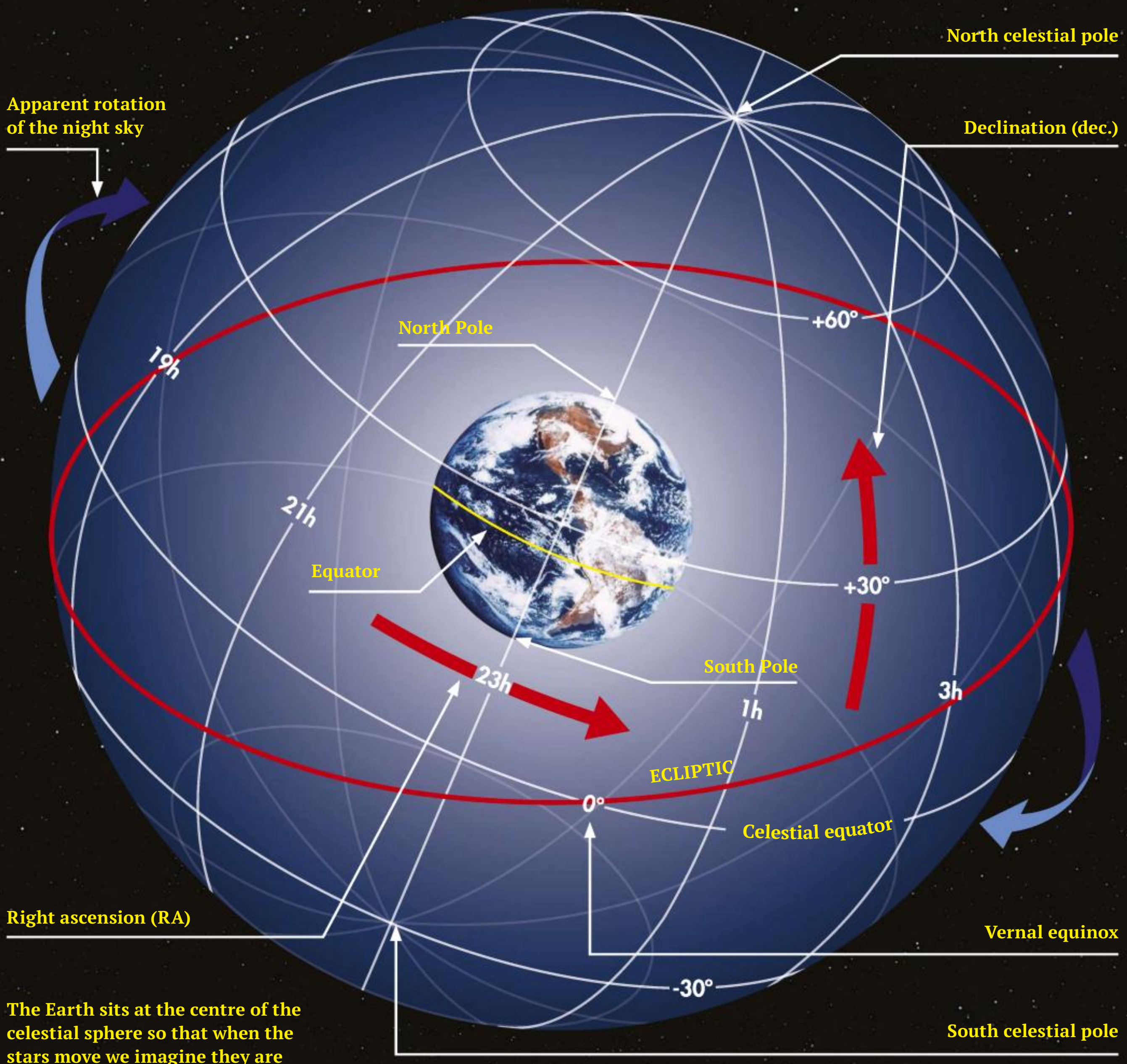
ISTOCK X 2

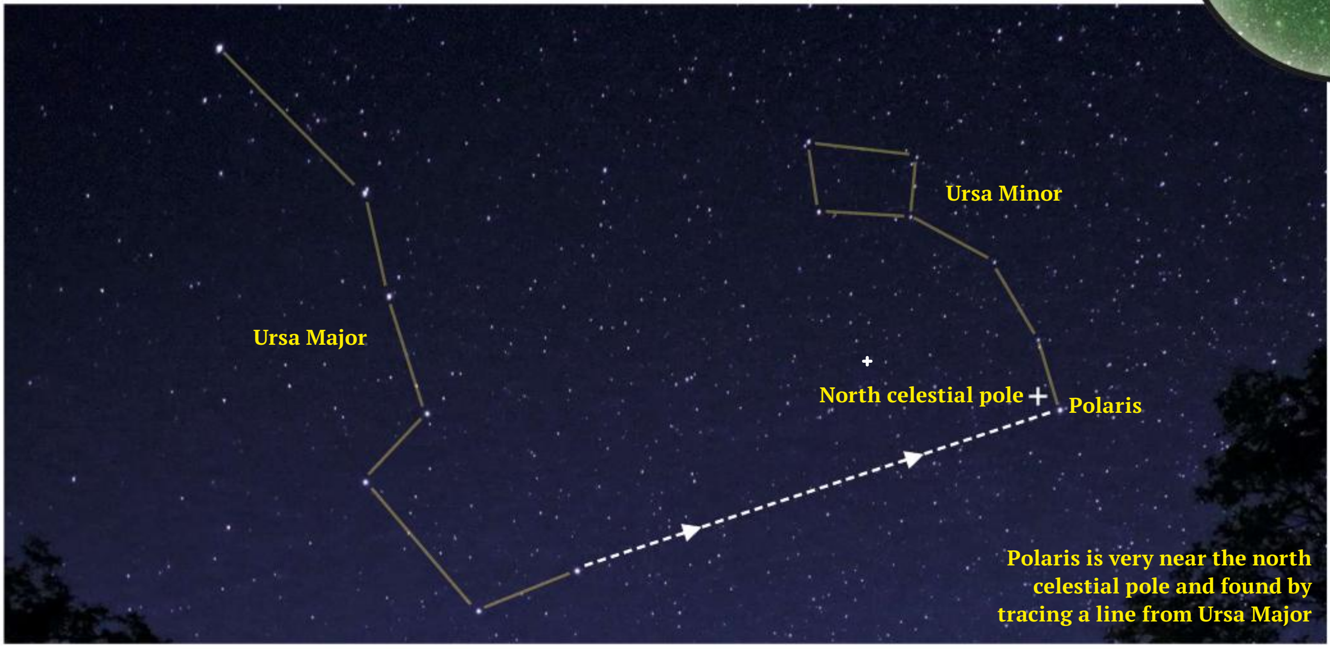
MAPPING THE NIGHT SKY

The celestial sphere is a system of imaginary lines that allows us to navigate the heavens



The Earth sits at the centre of the celestial sphere so that when the stars move we imagine they are 'fixed' to the inside of the sphere

ILLUSTRATION BY STEVE MARSH, ISTOCK, PAUL WHITFIELD



Polaris is very near the north celestial pole and found by tracing a line from Ursa Major

The actual distance between individual stars in space is immense, but not something you need to worry about when locating stars in the night sky. Celestial objects are all so far away from us that for observing purposes we consider them all to be the same distance away. This applies as much to a galaxy billions of lightyears away as it does to the Moon at just a few hundred thousand kilometres.

By assuming everything is at one distance, it allows us to describe the position of one celestial object in relation to another, as well as locate it in the sky. We do this using an imaginary construct called the 'celestial sphere'.

This is a large sphere with Earth at its centre and with north and south poles of its own. If you were to stand on Earth's north pole and look directly upwards, you would be looking at the north celestial pole (NCP); the reverse applies to the south celestial pole (SCP).

Conveniently, there is a mag. +2.0 star very close to the NCP – Polaris, in the constellation of Ursa Minor, and it acts as a marker for the NCP from any location in the northern hemisphere.

Directly above Earth's equator lies the celestial equator, an imaginary circle that divides the celestial sphere. Looking at the horizon from the poles would show stars located on the celestial equator. If you were to look up from Earth's equator, the celestial equator would stretch from the eastern horizon to the western horizon in an arc directly over your head and the celestial poles would lie at your northern and southern horizons.

Over a year, observers standing at the equator will see the whole celestial sphere, whereas those at the poles will only ever see their respective half of the sphere. At any point between the poles and the equator, you would see some stars from both halves.

There is a second key line on the celestial sphere; it's called the ecliptic and we'll explain its importance on page 48.

A GRID IN THE SKY

Mapping on the celestial sphere works much like mapping on Earth. For the celestial sphere, we throw the latitude and longitude Earth grid up into the sky. It's a mirror image with 'declination' for latitude and 'right ascension' for longitude.

Declination is how far an object is positioned above or below the celestial equator and is measured in degrees (°), arcminutes (') and arcseconds ("). Right ascension is an angular measurement in hours (h), minutes (m) and seconds (s) eastwards from a point on the celestial sphere known as the vernal equinox. This is the position of the Sun on the celestial sphere at the point it crosses the celestial equator at the spring equinox – the date in March when day and night are nearly equal in length. It's also the zero point for the entire grid.

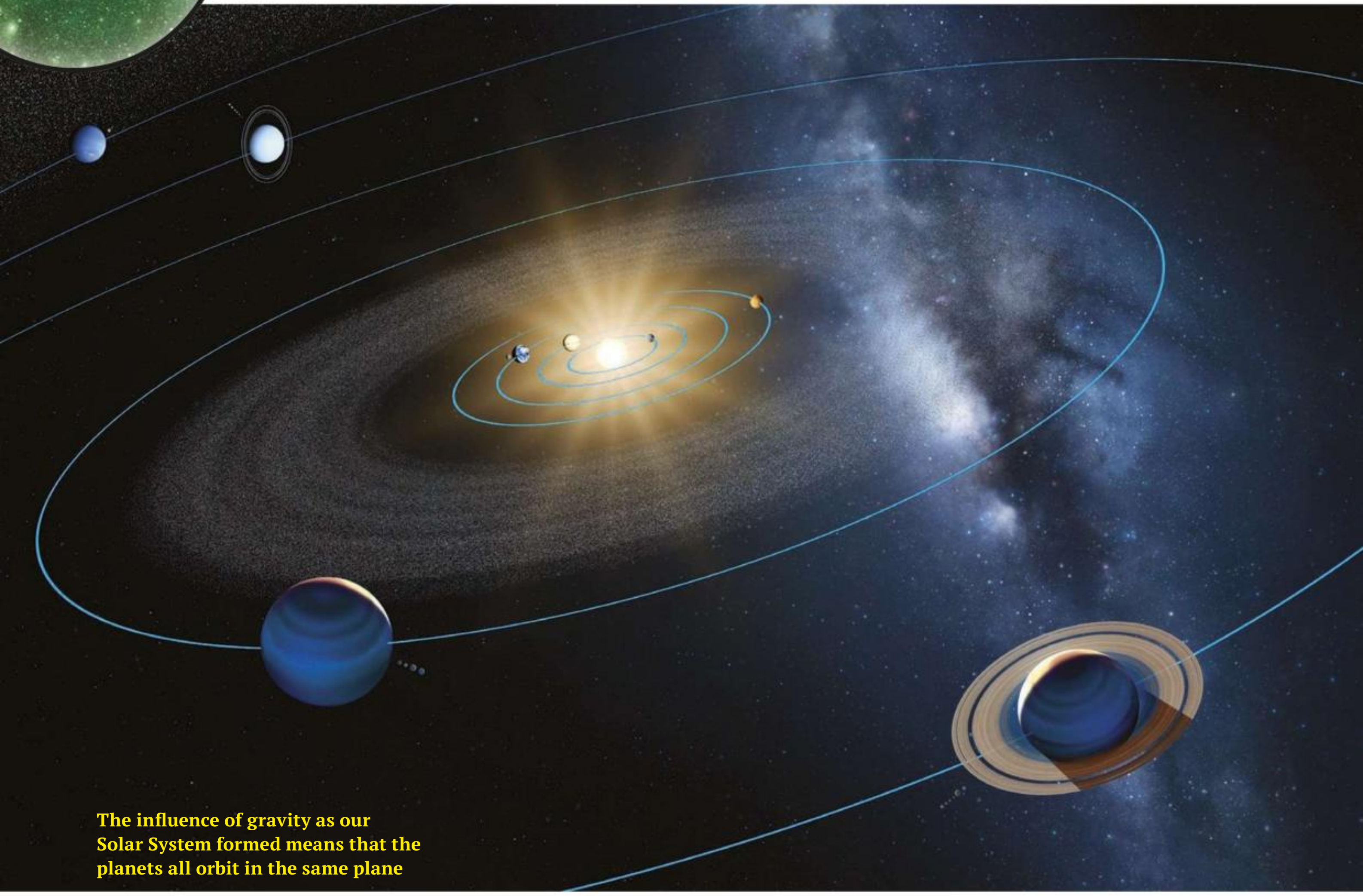
RA AND DEC. EXPLAINED

Every object in the night sky has celestial co-ordinates in right ascension (RA) and declination (dec.). For example, Deneb in Cygnus can be found at RA 20h 41m 25.9s, dec. +45° 16' 49".

In declination the ' symbol represents angular minutes (arcminutes) and the " represents angular seconds (arcseconds). A degree is a pretty large unit on the sky – two widths of the full Moon, in fact. So, 1° is divided into 60 arcminutes and each arcminute has 60 arcseconds. The + or – at the start shows whether an object is in the northern hemisphere (+) or in the southern hemisphere (–).

Right ascension is written as hours, minutes and seconds (as in regular time, not the arc variety). So, one hour in RA describes the movement of the sky due to Earth's spin over an hour – which is 15°, because 15 multiplied by 24 (hours) is 360°, and that's one complete rotation over a day.

Needless to say, star charts are all divided up so there's no need to convert anything – just plot the position and there, for instance, will be Deneb.



The influence of gravity as our Solar System formed means that the planets all orbit in the same plane

THE PATH OF THE SUN

The invisible course traced by the Sun as it moves across the sky is one of the most important lines in the celestial sphere

DETLEV VAN RAVENSWAAY/SCIENCE PHOTO LIBRARY, THINKSTOCK X 6

The Sun never deviates from the path that it traces across the sky. We can't see this line of course but we call it the 'ecliptic' and it's one of the most important markers in the sky. Why? Because the ecliptic also represents the orbital plane of our planet.

All of the planets in the Solar System occupy orbital planes similar to our own. This is because when the Solar System formed, billions of years ago, gravity pulled the dust and gas surrounding our nascent star into a kind of flat disc. The planets we know today all formed within this disc, so they all occupy planes similar to the ecliptic – described as 'coplaner'. Simply put, when the planets are visible, they will always be near the ecliptic.

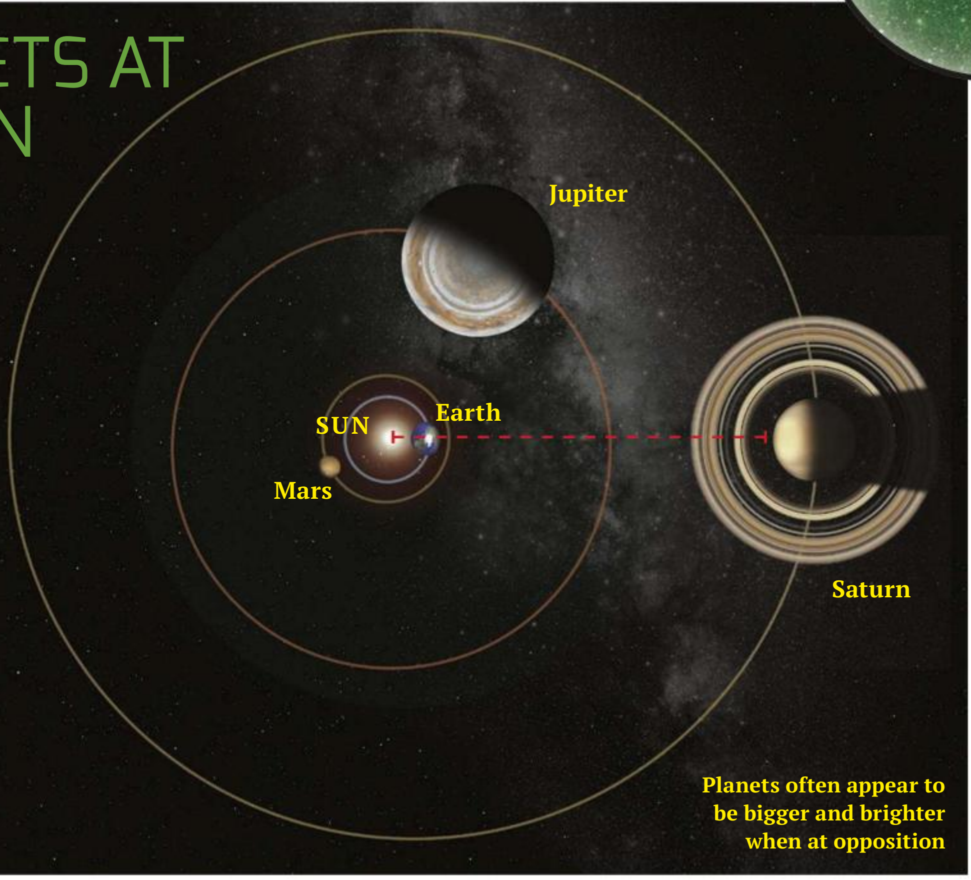
It's this coplanar nature of the Sun and planets that allows many of the events that captivate astronomers to happen so often. When our Moon and the Sun line up, we see an 'eclipse'. When a planet appears to be in the same part of the sky as another, or our own Moon, we call it a 'conjunction'. Even 'rare' events like a transit of Venus – when Venus passes between the Sun and a superior planet and appears as a small black disk moving across the face of the Sun – are quite frequent in cosmological terms.

THE EQUINOXES

The two points at which the ecliptic crosses the celestial equator mark the

THE PLANETS AT OPPOSITION

When the Sun, Earth and another planet form a line with Earth in the middle they are said be at 'opposition'. From our perspective on Earth, this means that the planet is in the opposite position in the sky to the Sun. This is another result of the Solar System being coplanar. This also means that only the superior planets – those with orbits further out from the Sun than Earth's – can be at opposition. A planet at opposition is usually at its closest to Earth and therefore appears larger than at any other time. Due to its position relative to the Sun, a planet at opposition can also appear brighter than usual, making this the best time to observe the planet on a clear night.



Planets often appear to be bigger and brighter when at opposition

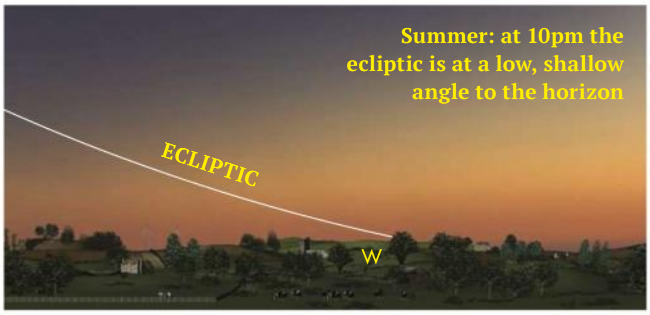
moments when the hours of day and night are roughly the same. These are called 'equinoxes', from the Latin for 'equal night'.

In the northern hemisphere, the equinox in mid-March signals spring, while the one in mid-September marks the beginning of autumn. At these two points in its orbit, Earth has no tilt relative to the Sun. From the March equinox, the days lengthen until mid-June, when Earth reaches the point in its orbit where it is at its greatest tilt relative to the Sun – a solstice. This is the first day of summer and the longest day of the year. At this point, the ecliptic and the celestial equator are at their furthest apart.

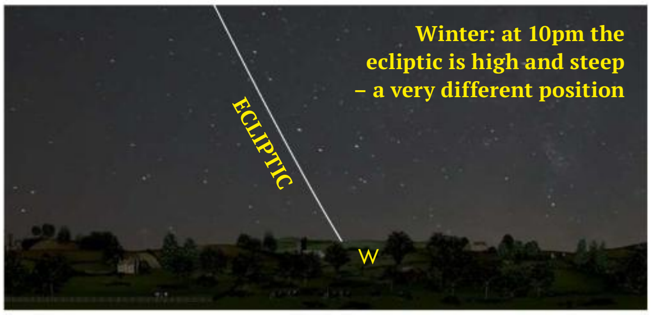
The second solstice six months later, in mid-December, when the tilt of the poles is reversed in relation to the Sun, marks the start of winter and the shortest day of the year in the northern hemisphere.

TRACKING THE ECLIPTIC

The Sun always sits on the ecliptic, so it's easy to work out where the line is on any clear day. Looking at the whole year, we know that the Sun – and hence the ecliptic – is higher in the sky through the day in the summer months and lower during the winter. But what about at night? If you can work out the path of the ecliptic across the night sky, you can work out where you might be able to spot a planet.



Summer: at 10pm the ecliptic is at a low, shallow angle to the horizon



Winter: at 10pm the ecliptic is high and steep – a very different position

SPRING

In the morning, the ecliptic sits low down, but in the evening it stretches high across the sky from east to west. This makes the dusk skies the best time to see Mercury and Venus, as they never stray far from the Sun.

SUMMER

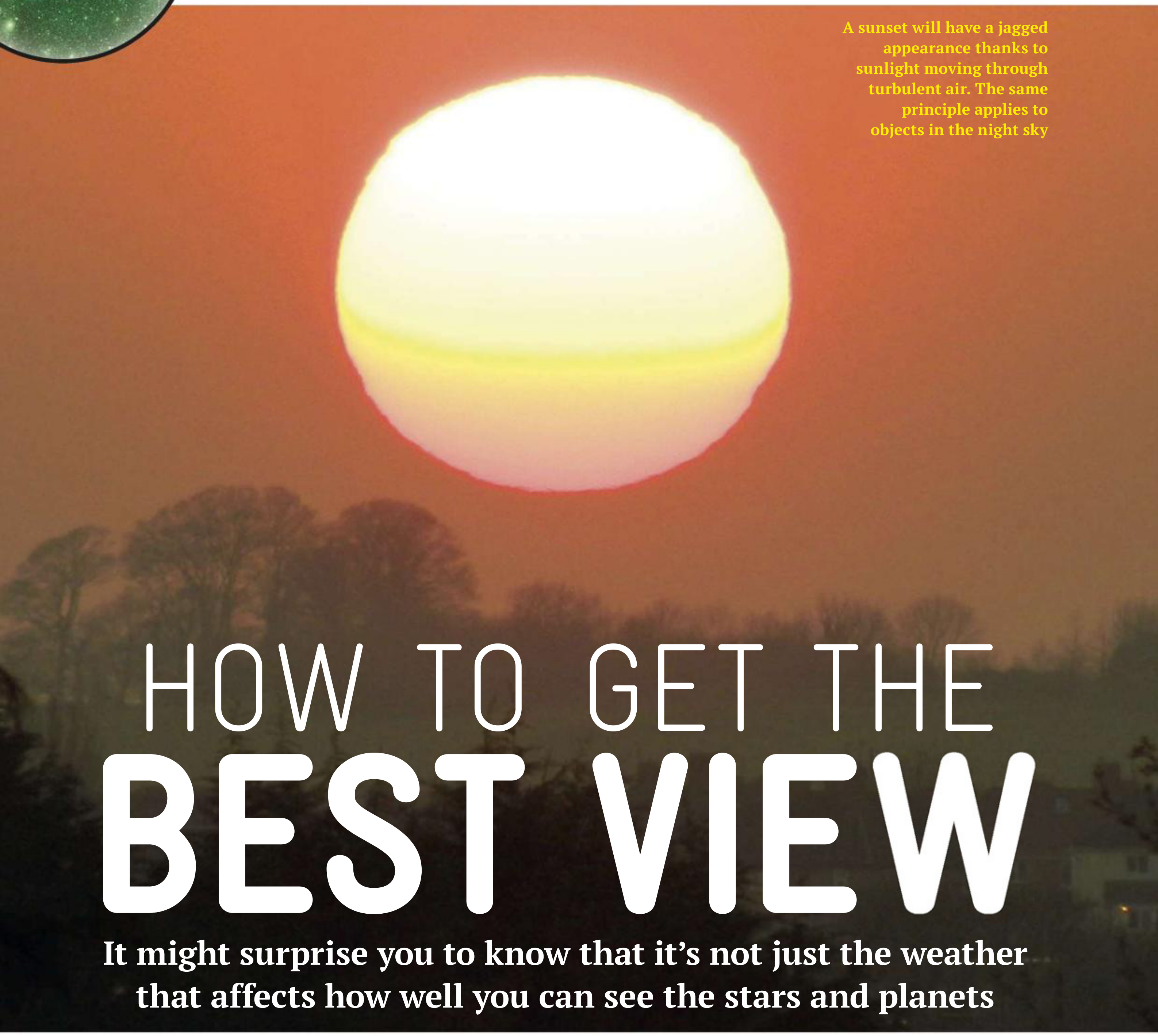
By dusk, the ecliptic sits at a low angle to the horizon, so any planets are hidden in atmospheric murk. The ecliptic's orientation swings from northwest-southeast in the evening to northeast-southwest in the morning.

AUTUMN

In a reflection of the northern hemisphere spring, the ecliptic's evening path is now low down, but in the morning it stretches high across the sky from east to west making dawn the best time to spot Mercury and Venus.

WINTER

In winter, the ecliptic path is quite high when it's dark and moves higher until it reaches maximum elevation at midnight. This is a great time to observe planets, as you're able to look at them through less atmosphere.



A sunset will have a jagged appearance thanks to sunlight moving through turbulent air. The same principle applies to objects in the night sky

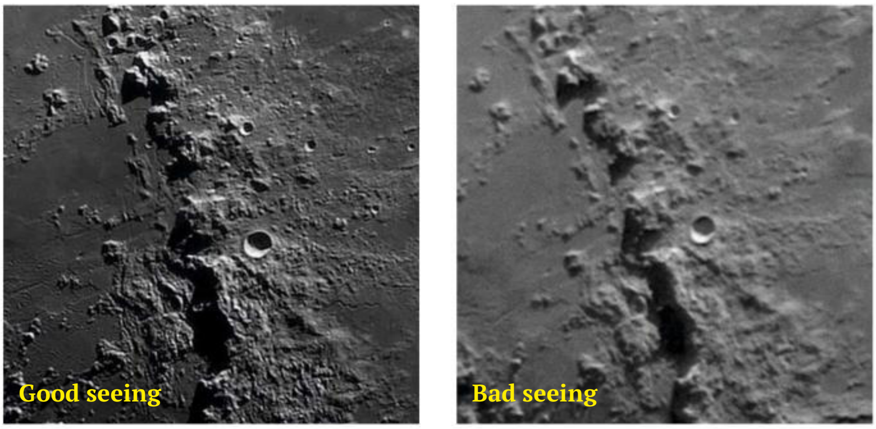
HOW TO GET THE BEST VIEW

It might surprise you to know that it's not just the weather that affects how well you can see the stars and planets

STEVE MARSH X 3, PETE LAWRENCE, THINKSTOCK, PAUL WHITFIELD

While it's certainly true that the weather is often a hindrance to a successful night's stargazing, you might be surprised to hear that even a clear night may not be the best time to go out and observe. The issue is the 'seeing'. In astronomy this doesn't mean how you look at something, it's a term that describes how much the view you see through your telescope is disturbed by what's going on in the atmosphere above and around you.

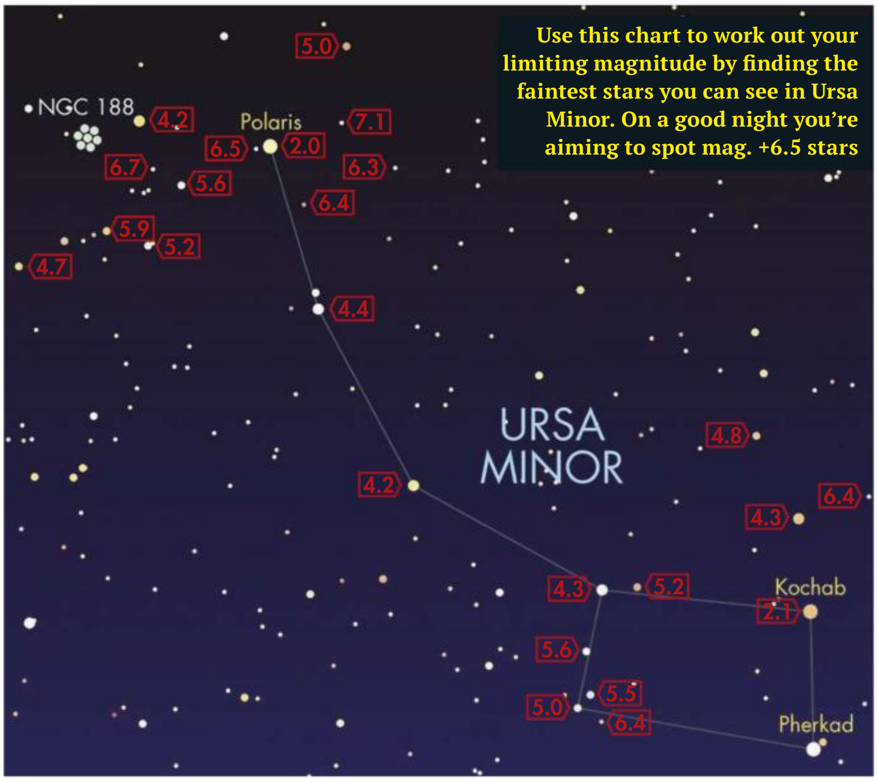
At times of good seeing, you'll get sharp, steady views through your telescope. But bad seeing produces



▲ Seeing can have a marked effect on telescopic views of the Moon, as these two images of the Lunar Apennines region taken under different conditions clearly show

YOUR LIMITING MAGNITUDE

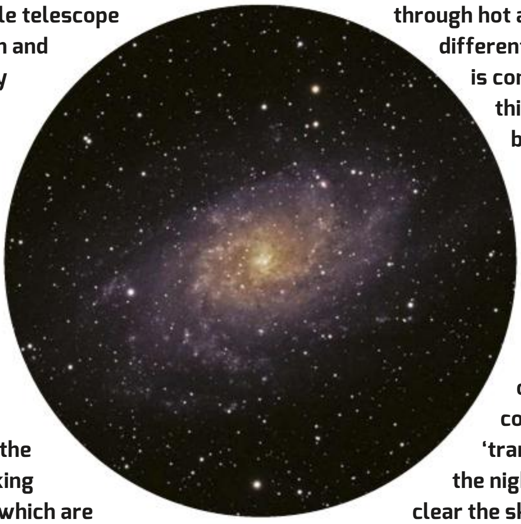
Atmospheric conditions affect the faintness of the stars you can observe. This chart will help you to check the faintest stars you can see by looking at Ursa Minor on a very clear night to work out your 'limiting magnitude'. This is the faintest star magnitude, or brightness, that you can see from your location – higher numbers mean fainter stars.



Use this chart to work out your limiting magnitude by finding the faintest stars you can see in Ursa Minor. On a good night you're aiming to spot mag. +6.5 stars

turbulent, unstable telescope views of the Moon and shuddering, shaky images of stars. (Deep-sky objects, such as galaxies and nebulae, aren't as badly affected by poor seeing.)

This is all due to the layers of moving air between you and the object you're looking at, the effects of which are magnified by your telescope. In the atmosphere, air at different temperatures is always moving around and mixing together. Light travels through hot and cold air at different speeds, so it is continually bent this way and that before it finally arrives at your telescope all shaken and stirred.



⮝ Deep sky objects benefit from good transparency and are not as badly affected by poor seeing conditions

The other factor that affects observing conditions is the 'transparency' of the night – just how clear the sky is. After it's been raining, the sky is transparent because the rain clears away particles of dust and smog from the air. However, when it's been raining it also tends to be windy, which means that the seeing is bad. You'll notice that the stars are twinkling because of this. Transparent conditions are, however, good for large, faint objects like nebulae and galaxies, which really benefit from the better contrast. Poor transparency generally means that although dust and particles are sitting in the still atmosphere, the air is steady with good seeing. These conditions are ideal for looking at the Moon and stars.

All this means that any moments of clarity are a wonderful thing as we really are at the mercy of the atmosphere when it comes to observing the night sky.

SETTING UP YOUR SCOPE

There's nothing you can do about the air currents far above you – 'high-level seeing' – but you can affect 'low-level seeing' to create steadier air conditions around you and your scope. Here's how:

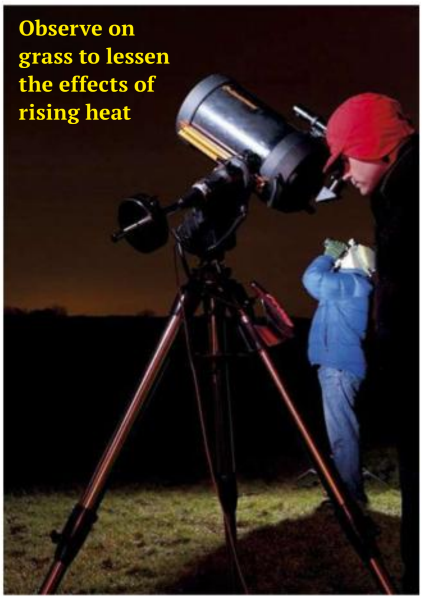
1 Leave your scope outside to cool to the ambient air temperature to get rid of any air currents in the tube.

2 Set up your scope on grass rather than concrete. Concrete absorbs more heat from the Sun and then radiates it out into the air above it for longer.

3 If possible, raise your scope up on a platform as air currents tend to stay low to the ground.

4 Choose thin materials, such as wood, that can cool quickly if you build yourself an observatory.

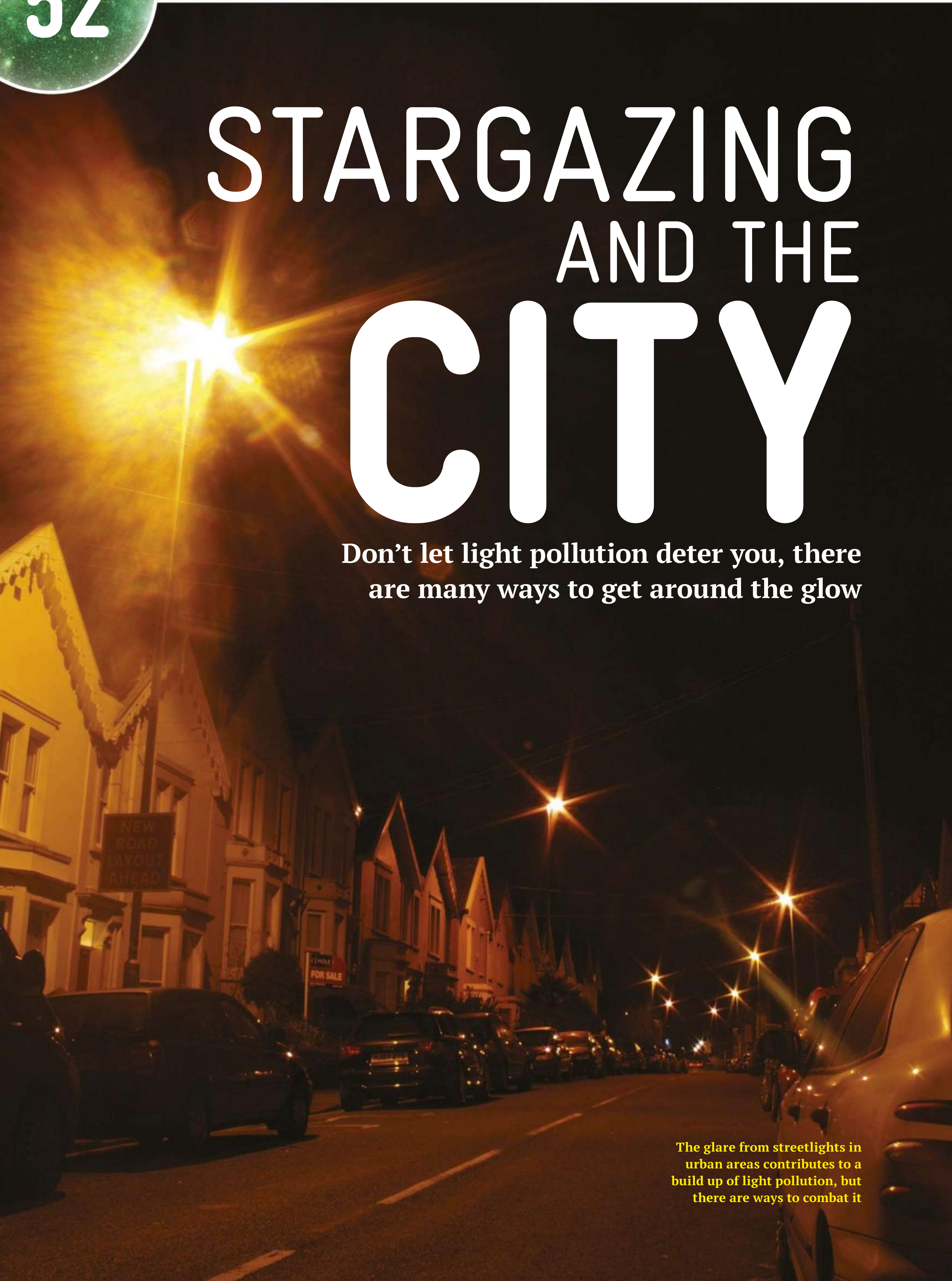
5 The nature of your observing site also affects how air behaves. Being near the sea gives you calmer air, whereas a range of hills will cause air turbulence as air is forced upwards.



Observe on grass to lessen the effects of rising heat

STARGAZING AND THE CITY

Don’t let light pollution deter you, there are many ways to get around the glow



The glare from streetlights in urban areas contributes to a build up of light pollution, but there are ways to combat it

From Snowdonia National Park in Wales to Exmoor in south west England and Scotland's Galloway Forest Park, there are now over 150 Dark Sky Discovery Sites in Britain, recognised for their lack of light pollution and good public access.

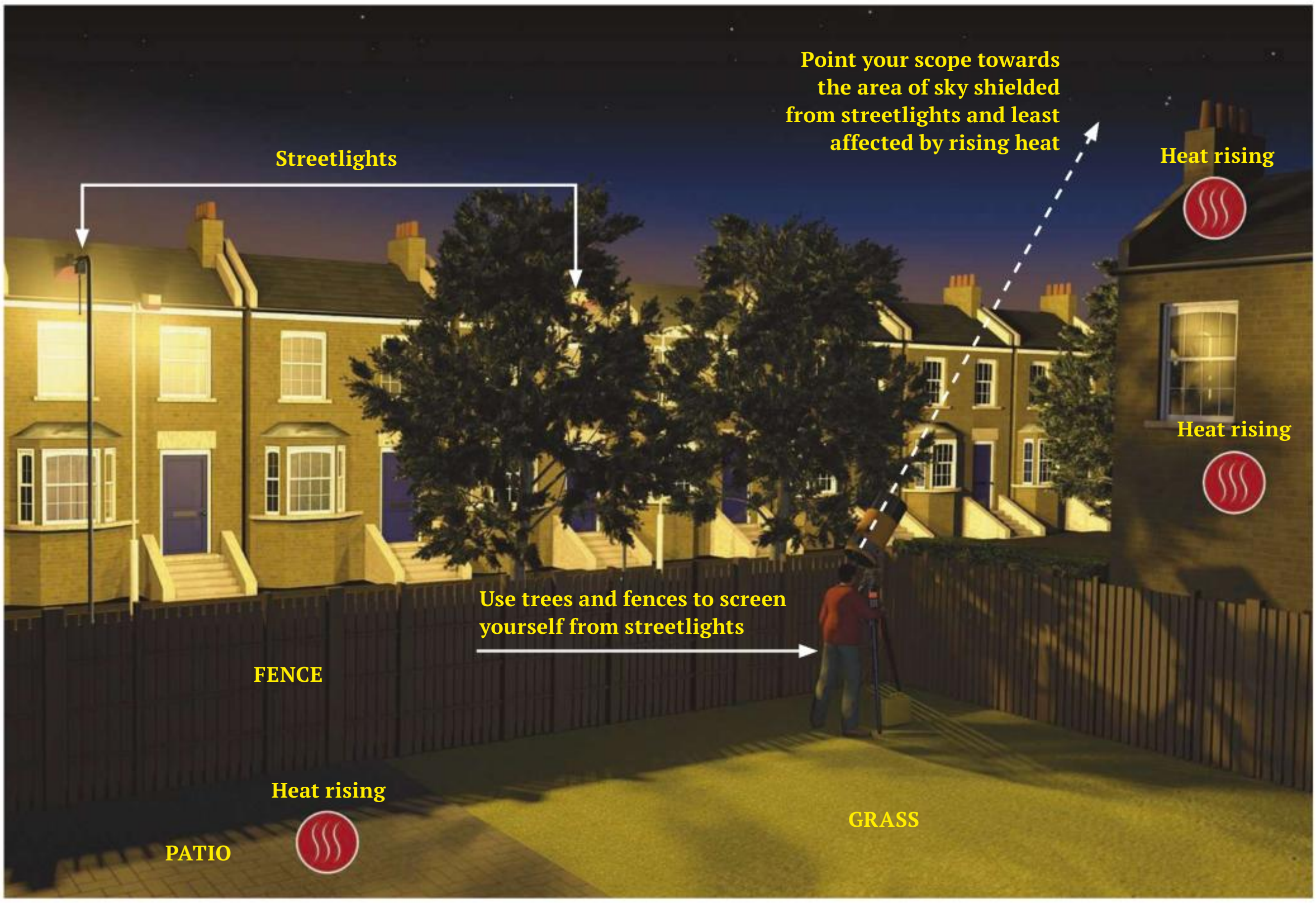
These designations are great news in terms of protecting the skies for future generations, and for a spot of practical astronomy if you are lucky enough to live within travelling distance of them. But for many of us, our stargazing is limited to the back garden and that often means dealing with light pollution.

This annoyance comes in two types – sky glow, the rusty orange haze cast by the massed lights over a wide area – and local glare from line-of-sight sources, such as streetlights, security lights and car headlights. Sky glow washes out the night and blots out the stars, while local sources are more prone to ruining your night vision. Under dark skies you can see stars down to mag. +6.5 with the naked eye, but light pollution can cut this to just a handful of first magnitude stars. Another common victim is the subtle river of the Milky Way, the beautiful band of stars that stretches high across the autumn skies.

The worst places for light pollution are inevitably large towns and cities, although even a rural location can be spoiled by the bright glare of a neighbour's security light. All is not lost, however, as there are a few tricks you can try to mitigate both glow and glare.

DEALING WITH LIGHT POLLUTION

- ➤ Position your scope in a spot that creates a barrier between yourself and the source of the glare – such as a fence, tree or building. Alternatively, make a suitable barrier.
- ➤ Make friends with your neighbours. In return for watering their plants while they're on holiday, they may agree to turning off an outside light or drawing their curtains when you are in the garden observing.
- ➤ Wait until after midnight to start observing as light pollution declines when people go to bed. And wait until your chosen target is well clear of the horizon before you attempt to view it.
- ➤ Optimise your equipment – choose eyepieces that have eye guards to block extraneous light and make sure lenses are free from eyelash grease. As an alternative to eye guards, throw a piece of blackout cloth over your head.
- ➤ Try a rolled up camping mat as a cheap dew shield to stop light getting in.
- ➤ Purchase a Go-To mount to help navigate to your intended targets if the glow above you is too bad.
- ➤ Add a light pollution filter (pictured) to your setup, and depending on your target, colour or narrowband filters can also help to increase clarity and enhance detail.


Point your scope towards the area of sky shielded from streetlights and least affected by rising heat
Streetlights
Heat rising
Heat rising
Use trees and fences to screen yourself from streetlights
FENCE
Heat rising
PATIO
GRASS

STEVE MARSH, PAUL WHITFIELD, ILLUSTRATION BY PAUL WOOTTON

▲ Try to position your scope on grass, protect it from external lights and point it between or away from heat sources like roofs

TOP TIPS FOR STARGAZING

Follow this practical advice and enjoy a good first night under the stars

1. THE EYES HAVE IT

Forget the myth that to be a 'proper' astronomer you need to have a telescope – this is complete rubbish! There are myriad things you can see with the naked eye alone – from the constellations to meteor showers, the band of the Milky Way and even the occasional galaxy. If you want to take things further, consider investing in a pair of binoculars before a telescope – you'll be able to see more of the night sky without dealing with the practicalities of setting up.

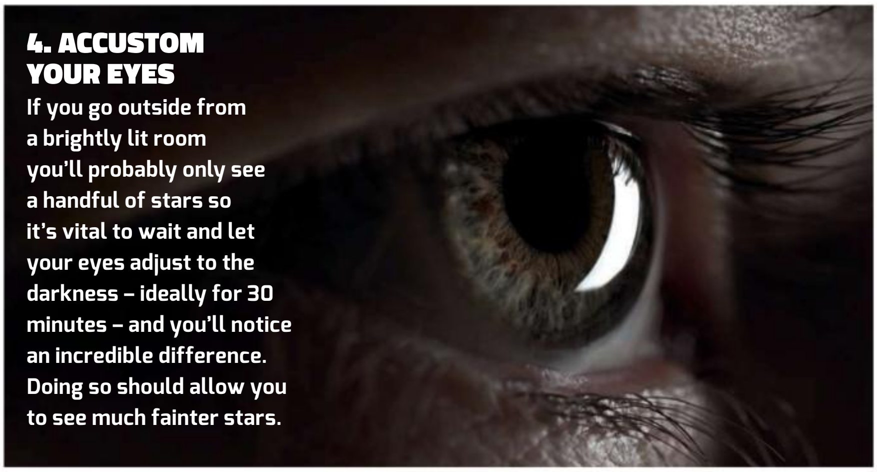
2. KEEP OUT THE COLD

We know it's not rocket science (if you'll excuse the pun), but astronomy involves a lot of time outdoors being still, so it's important to stay warm. Several layers of thin clothing are recommended, as are waterproof shoes, a hat and gloves. If you have pages to turn or equipment (especially touchscreens) to operate, fingerless gloves are ideal.

JON HICKS, ISTOCK X 6, BBC

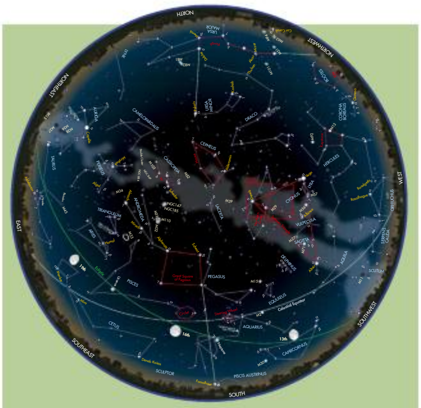
3. GIVE YOUR NECK A REST

If you stand still staring up at the sky you'll soon find that you get neck ache. So avoid the pain entirely by finding something that you can lie back on. A reclining garden chair, a sunlounger or an old-fashioned deck chair are ideal, but your spine will thank you even if all you have to hand is a camping groundsheet, a yoga mat or a waterproof picnic blanket to spread over the grass.



4. ACCUSTOM YOUR EYES

If you go outside from a brightly lit room you'll probably only see a handful of stars so it's vital to wait and let your eyes adjust to the darkness – ideally for 30 minutes – and you'll notice an incredible difference. Doing so should allow you to see much fainter stars.



5. USE A STAR CHART

These are a great way to learn your way around the night sky. Astronomy magazines publish star charts every month or you can buy a book. You can begin by identifying patterns of bright stars. From there you can gradually learn your way around the constellations, and before too long they'll become familiar and you'll be able to navigate your way around the night sky without reference to a book or chart.

6. BRING A RED TORCH AND A COMPASS

A red-light torch is a must when you've given your eyes time to adjust to the dark but still want to see your star charts. This is because dark-adapted eyes are much less sensitive to red light than they are to white. You can buy a red-light night vision torch, or make one by taking a regular torch and sticking a piece of red acetate over the front. A compass will help you find north, which is essential not only when using star charts but also in setting up your telescope mount.

7. STAY AWAY FROM STREETLIGHTS

If you can, head out to the countryside to take advantage of properly dark skies. But if you are observing in an urban area, shield yourself from any artificial light sources, as they will prevent your eyes from acclimatising to the dark.

8. SLOW AND STEADY

No one has ever looked at the night sky and instantly understood how to find their way around; there really is a lot to see up there! Not even the legendary Sir Patrick Moore was immune to this – he honed his knowledge by memorising one new constellation each night.

Once you've set the chart to match the current date and time, you'll be able to see which stars are in the sky

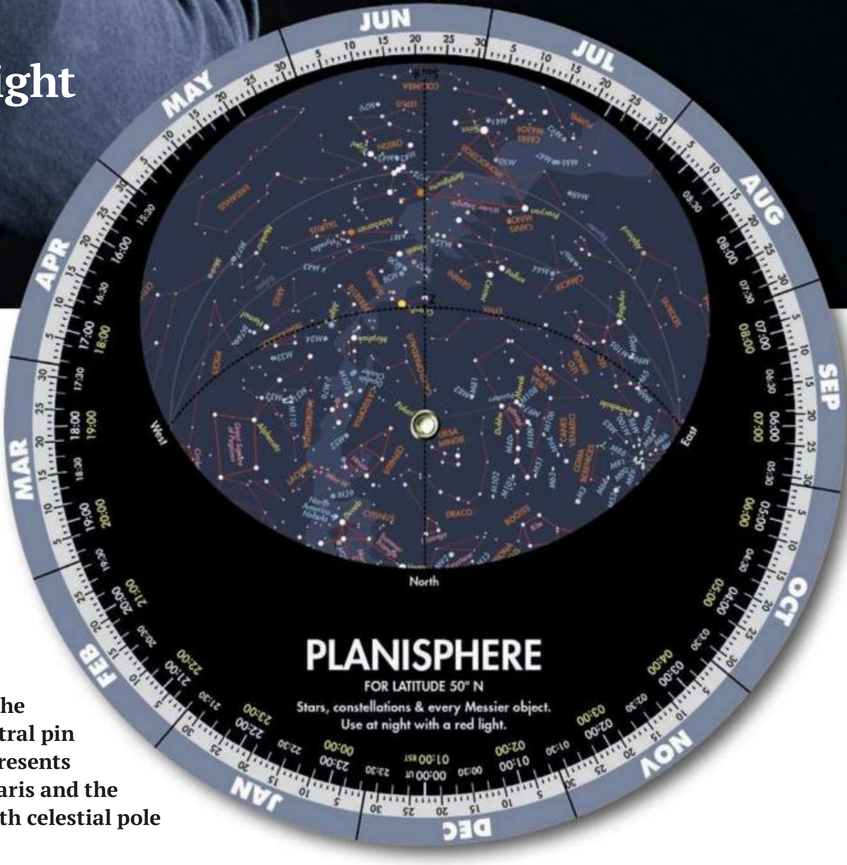
HOW TO USE A PLANISPHERE

When you need to find your bearings in the night sky a planisphere is indispensable, even in our digital age

They don't look like much – usually a planisphere is simply two discs of cardboard or plastic fastened together with a central pin – but as a new stargazer, you'll soon discover that this tool is one of the greatest aids to helping you navigate the night sky. In fact, this deceptively simple design will allow you to work out which bright stars are in the night sky on any date and at any time throughout the year.

Although the two discs are pinned together, they can still be rotated independently of each other. Printed over most of the lower disc are the stars,

WWW.SECRETSTUDIO.NET X 2, STEVE MARSH X 3



➤ The central pin represents Polaris and the north celestial pole constellations and brighter deep-sky objects that you can see from a given latitude. Marked around the outside of this lower disc are the days and months.

LATITUDE MATTERS

The upper disc will be slightly smaller than the lower one or will have a clear rim, so you can still see the day and month markings underneath. It also has an oval window in it, revealing part of the star chart on the lower disc. The edge of this window represents the horizon with appropriate north, south, east and west markings and everything within it is the visible sky. Just like the lower disc, the upper disc has markings around its edge. In this case, they indicate the time of day. By lining up the date and time, the stars visible in the window will match the ones in the night sky at that time.

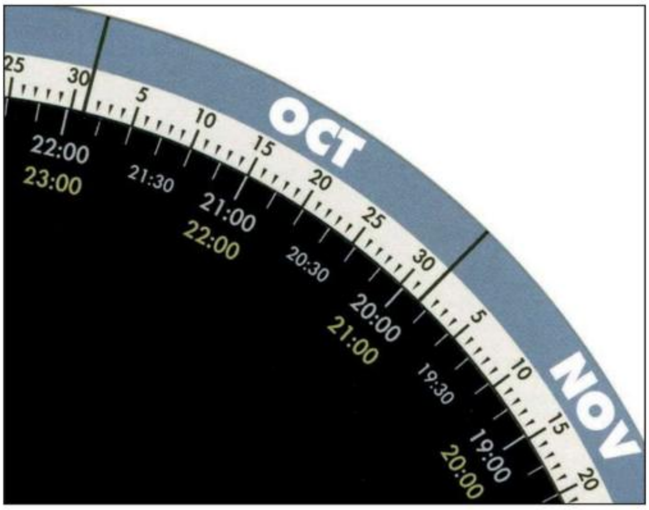
The crucial point to keep in mind when using a planisphere is that they are designed to work at specific latitudes. If you try using one too far north or south of the location it has been intended for, you'll find that the stars don't appear in the right positions. Both Philip's and the David Chandler Company produce planispheres for UK latitudes, which vary from 50°N in southern England to 60°N in northern Scotland.

GETTING STARTED

Follow these simple steps and you'll soon be navigating the night sky like a pro

1 FIND YOUR BEARINGS

Before you can start using your planisphere you need to know the cardinal points from where you live. If you don't have a compass, use the Sun. It rises roughly in the east and sets roughly in the west. You can also download a free compass app for most smartphones.

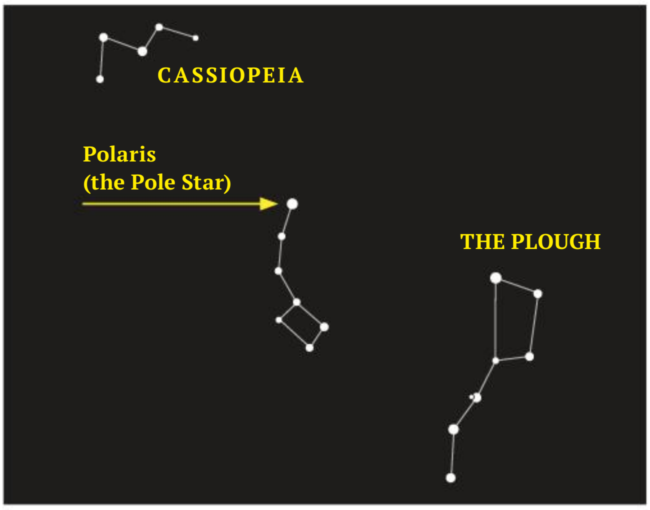


2 SET THE TIME AND DATE

Let's imagine that you are heading out to observe at 9pm on 15 October. Spin the upper disc to align the 9pm marker on this disc with the 15 October marker on the lower disc. The stars in the oval window should now match the stars in the night sky above you.

3 LOOK TO THE NORTH

Look north to begin with, holding the planisphere up so that the word 'north' is at the bottom. If you change the direction you're facing, you need to move the planisphere round so that the compass point sitting at the bottom corresponds with the direction you're facing.

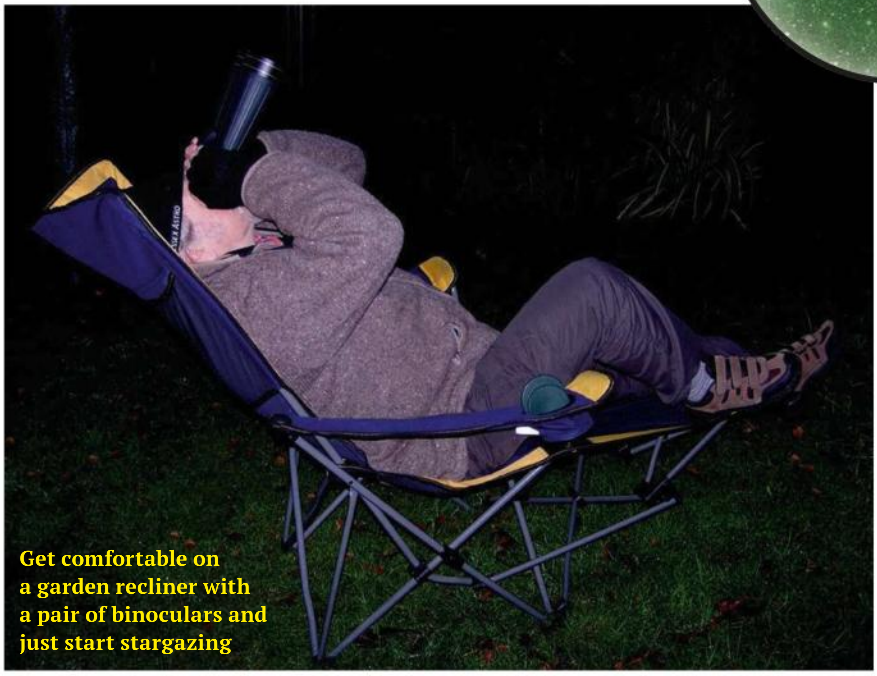


4 START AT THE PLOUGH

Helpfully, the central pin in your planisphere represents Polaris and the north celestial pole. Just to its lower right will be the seven bright stars of the Plough asterism. Use the Plough and the five stars forming the distinct 'W' shape of Cassiopeia to get to know the constellations.

STARTING WITH BINOCULARS

Telescopes aren't the only option for observing the night sky, a pair of binoculars is ideal for budding astronomers



Get comfortable on a garden recliner with a pair of binoculars and just start stargazing

New to astronomy and trying to work out what to buy for your first telescope? There's a simple answer to that question: don't buy one, buy two. Two small scopes joined with a hinge so that the distance between them can be adjusted to exactly match your eyes – binoculars. Binoculars allow you to observe hundreds of astronomical objects. Not only can you see many more objects through binoculars than with the naked eye, but the detail and colour you can see will become richer too.

Binoculars are still suitable even if you want to do 'serious' astronomy. There are variable star observing programmes designed specifically for binoculars and being lightweight and easy to carry makes them ideal for getting out and about to view a lunar graze or asteroid occultation.

Closer to home, why not simply wrap up warm, lie back on your garden recliner and just enjoy the objects your binoculars let you find as you cast your gaze among the stars. You'll soon be able to find your way around the night sky and navigate better than with the entry-level Go-To telescope you nearly bought instead.

Your pocket will thank you too, as you can invest in a good pair of binoculars for less than the cost of one reasonably good telescope eyepiece.

WHAT SIZE SHOULD YOU BUY?

You'll notice that binoculars are classified by two numbers, their magnification and aperture. A 10x50 pair of binoculars has a magnification of 10x and each of the front lenses has an aperture of 50mm. These numbers also allow you to work out the size of the circle of light, or 'exit pupil', that emerges from the eyepieces: to do this you divide the aperture by the magnification. This means a 10x50 pair of binoculars has an exit pupil of 5mm. The exit pupil should be no larger than the dark-dilated pupils of your eyes: so a pupil of anywhere between 4-6mm is fine for your first pair of binoculars.

Larger apertures can show you more but being heavier you will probably need to use a mount to keep a steady view over a longer period. The most common sizes are:

1 **8x40:** almost anyone over the age of 10 can hold these steadily.

2 **10x50**: most adults can hold these steadily, so this size is a popular compromise between size and weight.

3 **15x70**: this size really needs to be mounted, although they can be held for short periods.

It's also important to check that the distance between the two eyepieces will adjust to your eyes. If you wear glasses, check that the binoculars have enough distance from the eyepiece to your ideal eye position; 18mm or more should be adequate. Finally, there are two basic types of binoculars: Porro-prism and roof-prism. In any price range, roof-prisms are lighter but Porro-prisms tend to have better optical quality. Once you've decided on the size and type that best suits you, go for the best quality you can buy for your budget.

Bigger isn't necessarily better: larger binoculars are harder to hold steady and less magnification will actually give you a clearer view of large night-sky objects

PAUL WHITFIELD X 4, ISTOCK, STEPHEN TONKIN

CHOOSING A TELESCOPE

Keen to buy your first telescope? Our simple guide will help you find the best fit for you

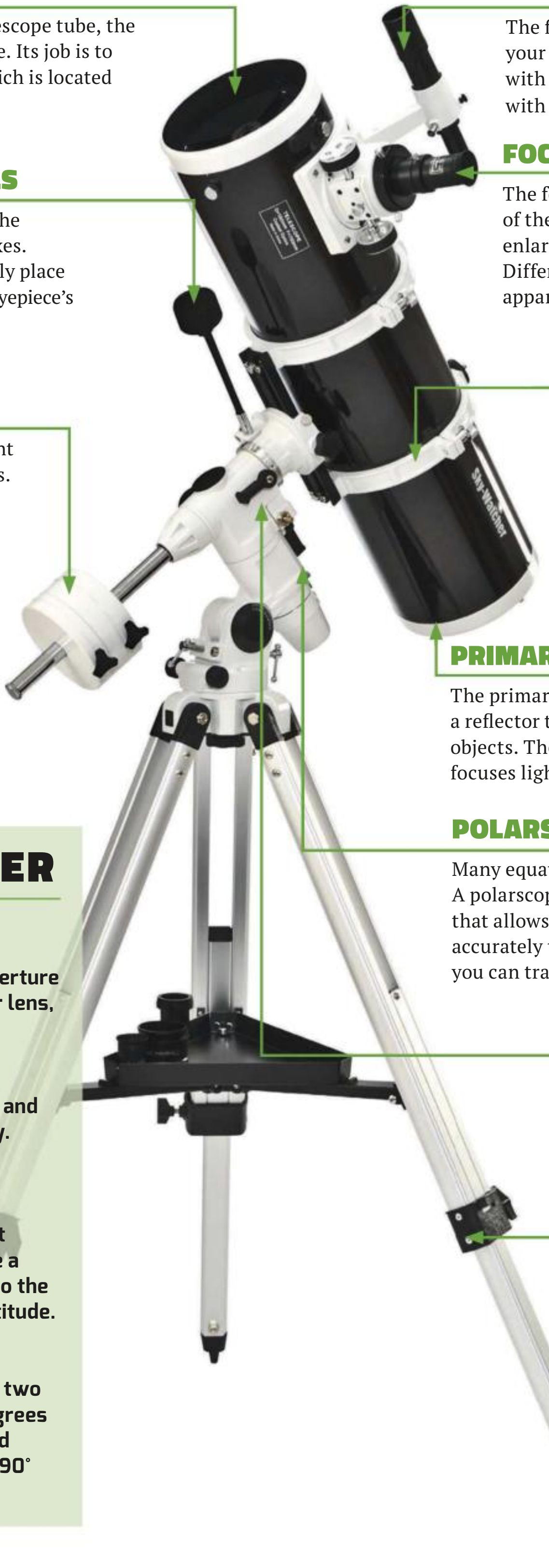
Your stargazing journey is sure to be a rewarding one filled with exploration and discovery. Sights of the planets, stars, nebulae and galaxies, among many other wonders, all await. Choosing your first telescope is part of that exciting adventure but it's not always an easy business. There's an array of equipment and technical terminology waiting to entice and confuse you, so here we take a straightforward look at the four most common types of telescope and how they work, to give you a better idea of your options before you buy.

Investing in a scope will let you explore many more of the marvels in the night sky

REFLECTOR

Reflectors use a specially curved main mirror to collect celestial light and were invented by Sir Isaac Newton. In the Newtonian design (shown here, below), the light collected by the primary (main) mirror is reflected and focused back up the telescope's tube to a much smaller, flat, 'secondary' mirror supported by wires in the centre of the tube. This secondary mirror is angled at 45° to send the light beam out to the side, passing through a focuser and eventually into an eyepiece, the part that you look through.

BEST FOR: Deep sky objects, planets and the Moon. Both visual astronomy and astrophotography. Large apertures are more affordable with this type of scope.



SECONDARY MIRROR

Located towards the front of the telescope tube, the secondary mirror is set at a 45° angle. Its job is to reflect the light into the focuser, which is located on the side of the tube.

SLOW-MOTION CONTROLS

Slow-motion controls let you move the telescope manually in one or both axes. Using these controls you can carefully place a celestial object in the centre of the eyepiece's field of view and then keep it there.

COUNTERWEIGHTS

Balancing the telescope on the mount requires one or more counterweights. This reduces the strain on any motorised drives and can prevent the scope from falling over.

JARGON BUSTER

APERTURE

This is the most important specification of a telescope. Aperture is the size of the main mirror or lens, usually given in inches.

MOUNT

The mount holds the telescope and allows you to point it at the sky. There are two main types:

EQUATORIAL

These mounts align to the night sky's axis of rotation. They use a coordinate system mapped onto the sky similar to longitude and latitude.

ALTAZIMUTH

These are mounts that move in two axes: azimuth (measured in degrees from north) and altitude (up and down from 0° at the horizon to 90° right above your head).

FINDERSCOPE

The finderscope will help you home in on your target. It can either be a mini telescope with a wide field of view or a red-dot finder with no magnification.

FOCUSER AND EYEPIECE

The focuser allows you to adjust the position of the eyepiece to make the view crisp. Eyepieces enlarge the view produced by the telescope. Different eyepieces can be used to increase the apparent size of your target.

TUBE RINGS AND DOVETAIL BAR

The tube rings hold the telescope tube so that you can rotate it to a comfortable viewing position. The rings attach to a 'dovetail' bar (the black bar running between the two tube rings), which is used to secure the tube to a mount.

PRIMARY MIRROR

The primary (main) mirror, which is at the bottom of a reflector telescope's tube, collects light from distant objects. The mirror is specially curved so that it focuses light back up towards the secondary mirror.

POLARSCOPE

Many equatorial mounts have one of these built in. A polarscope is effectively a miniature telescope that allows you to align one axis of the mount very accurately to the rotation axis of the night sky, so you can track the stars more easily.

MOUNT HEAD

The mount head for a Newtonian telescope is usually an equatorial design like this one. This allows you to align the mount to the night sky in order to track the stars.

TRIPOD

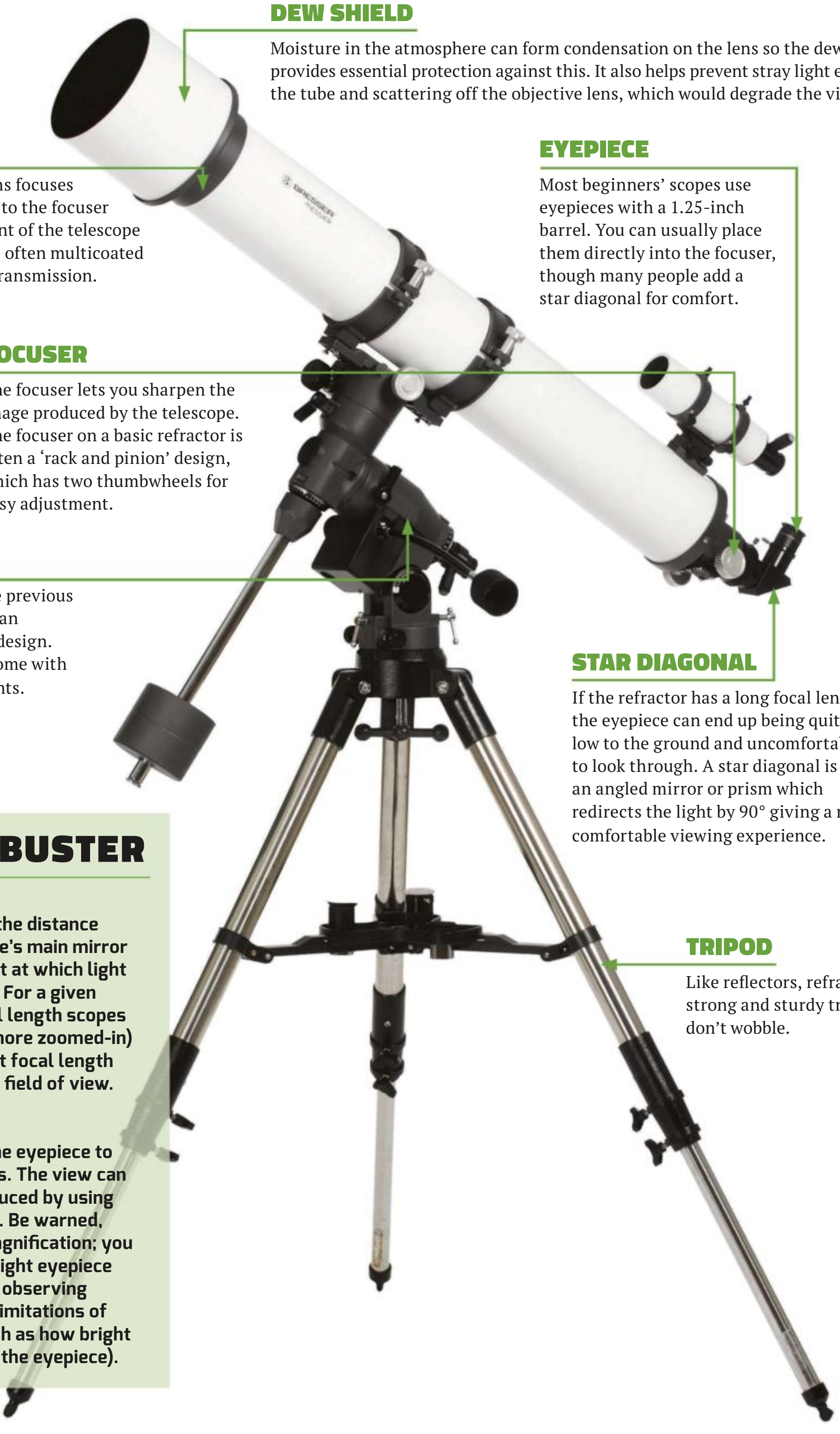
Tripods are usually made of aluminium and provide support for the whole system. They have adjustable legs so that you can vary the height of the telescope for ease of use. The tripod must be stable and give firm support.

ISTOCK, PAUL WHITFIELD

REFRACTOR

The oldest and simplest telescope design, Galileo used a refractor to record the phases of Venus, among other things. Refractors have a curved lens at the front, which focuses the light down the tube directly to the focuser. An angled mirror or prism called a star diagonal, which bends the light through 90°, is often added between the focuser and the eyepiece to make viewing more comfortable.

BEST FOR: Deep sky objects, double stars and planets. Generally used for visual astronomy; for astrophotography go for a more expensive version with an equatorial mount.



DEW SHIELD

Moisture in the atmosphere can form condensation on the lens so the dew shield provides essential protection against this. It also helps prevent stray light entering the tube and scattering off the objective lens, which would degrade the view.

OBJECTIVE LENS

The objective (main) lens focuses the light down the tube to the focuser and is located at the front of the telescope tube. Modern lenses are often multicoated to provide better light transmission.

EYEPIECE

Most beginners' scopes use eyepieces with a 1.25-inch barrel. You can usually place them directly into the focuser, though many people add a star diagonal for comfort.

FOCUSER

The focuser lets you sharpen the image produced by the telescope. The focuser on a basic refractor is often a 'rack and pinion' design, which has two thumbwheels for easy adjustment.

MOUNT HEAD

Like the reflector on the previous page, this refractor has an equatorial mount head design. Many basic refractors come with simple altazimuth mounts.

STAR DIAGONAL

If the refractor has a long focal length the eyepiece can end up being quite low to the ground and uncomfortable to look through. A star diagonal is an angled mirror or prism which redirects the light by 90° giving a more comfortable viewing experience.

TRIPOD

Like reflectors, refractors need strong and sturdy tripods that don't wobble.

JARGON BUSTER

FOCAL LENGTH

The focal length is the distance between a telescope's main mirror or lens and the point at which light is brought to focus. For a given eyepiece, long focal length scopes show a narrower (more zoomed-in) view, whereas short focal length scopes give a wider field of view.

EYEPIECES

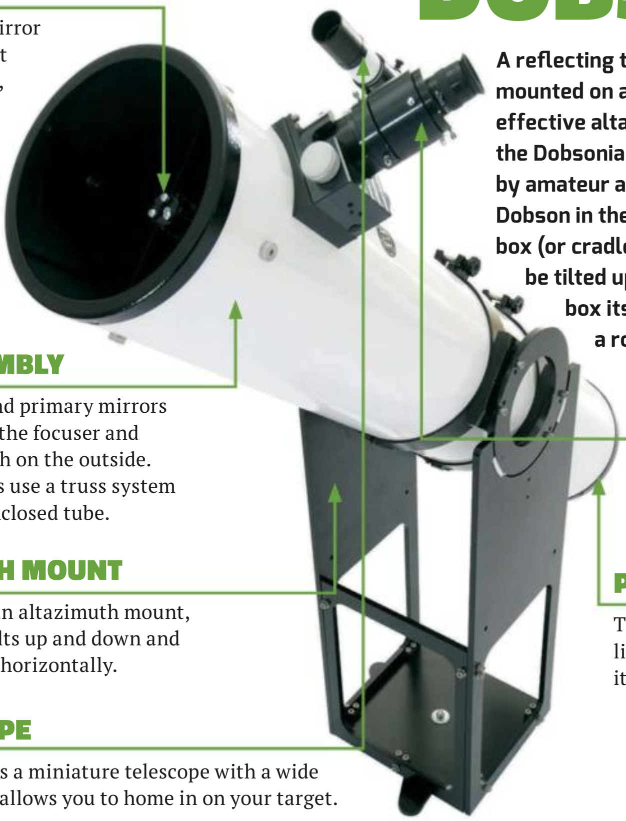
You look through the eyepiece to see celestial objects. The view can be magnified or reduced by using different eyepieces. Be warned, it's not all about magnification; you should choose the right eyepiece to use based on the observing conditions and the limitations of your telescope (such as how bright the view is through the eyepiece).

PAUL WHITFIELD X 3

DOBSONIAN

A reflecting telescope mounted on a simple but effective altazimuth mount, the Dobsonian was popularised by amateur astronomer John Dobson in the 1960s. It sits in a box (or cradle) that allows it to be tilted up and down. The box itself is mounted on a rotatable platform, so you can turn the telescope from left to right. Basic Dobsonians can't track the stars, but their simple design means you can often get a larger aperture scope for your money.

BEST FOR: Deep sky objects, planets and the Moon. Visual astronomy. Large apertures on a simple, easy to use mount.



SECONDARY MIRROR

The secondary mirror redirects the light path through 90°, out towards the side of the tube to the focuser.

TUBE ASSEMBLY

The secondary and primary mirrors are housed here; the focuser and finderscope attach on the outside. Some Dobsonians use a truss system rather than an enclosed tube.

ALTAZIMUTH MOUNT

Dobsonians use an altazimuth mount, where one axis tilts up and down and the other rotates horizontally.

FINDERSCOPE

The finderscope is a miniature telescope with a wide field of view that allows you to home in on your target.

FOCUSER AND EYEPIECE

The eyepiece and focuser assembly sits at the top of the tube and juts out from the side of the telescope, as in the Newtonian design.

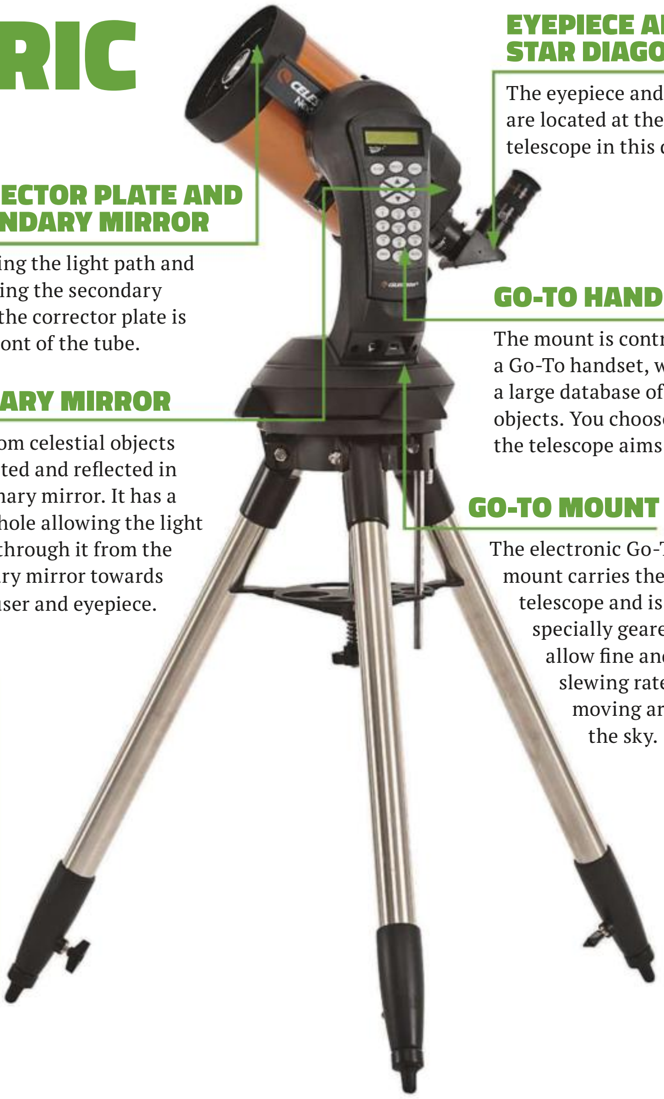
PRIMARY MIRROR

The primary mirror collects and focuses the light from distant celestial objects and reflects it back up to the secondary mirror.

CATADIOPTRIC

Catadioptric, or compound, telescopes use a combination of a mirror and a front corrector lens to capture and focus celestial light in a compact and much shorter tube than refractors or reflectors. Light comes out of the rear; a star diagonal and eyepiece are used for a comfortable viewing position. Popular designs include the Schmidt-Cassegrain and Maksutov-Cassegrain. Compound scopes can be mounted on equatorial mounts but are often found on altazimuth Go-To mounts.

BEST FOR: Planets, The Moon and the Sun (with a filter). Both visual astronomy and astrophotography. Compact design fits a longer focal length into a compact tube.



CORRECTOR PLATE AND SECONDARY MIRROR

Correcting the light path and supporting the secondary mirror, the corrector plate is at the front of the tube.

PRIMARY MIRROR

Light from celestial objects is collected and reflected in the primary mirror. It has a central hole allowing the light to pass through it from the secondary mirror towards the focuser and eyepiece.

EYEPIECE AND STAR DIAGONAL

The eyepiece and star diagonal are located at the rear of the telescope in this design.

GO-TO HANDSET

The mount is controlled by a Go-To handset, which holds a large database of celestial objects. You choose one and the telescope aims itself at it.

GO-TO MOUNT

The electronic Go-To mount carries the telescope and is specially geared to allow fine and fast slewing rates for moving around the sky.

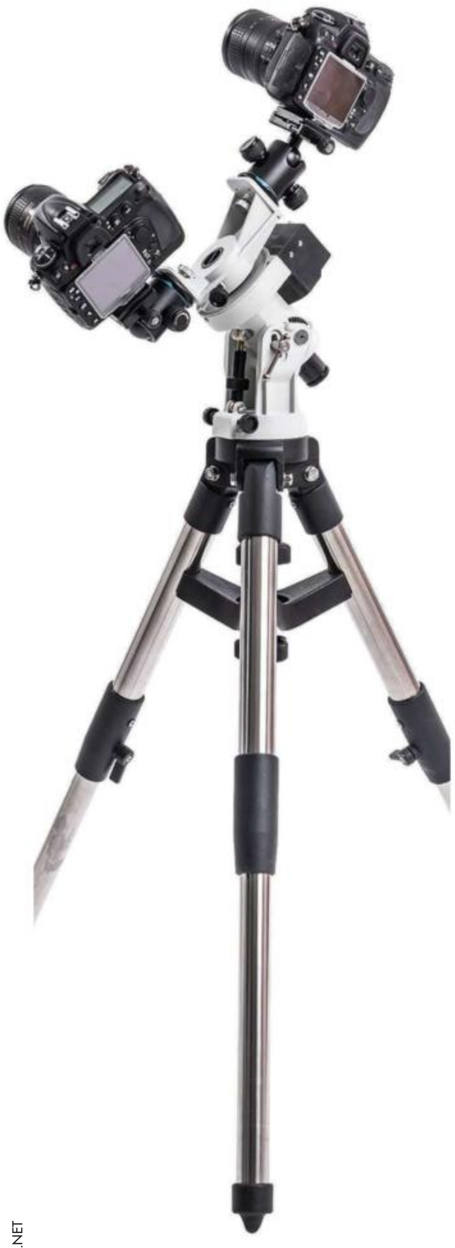
JARGON BUSTER

GO-TO

Some mounts are fitted with motorised drives and computer handsets capable of aligning and controlling a telescope, as well as pointing it at selected celestial objects. These 'Go-To' mounts make viewing many objects light work, however it's not the best way to learn your way around the night sky if you use one when starting out.

GET THE RIGHT TELESCOPE MOUNT

Here's the lowdown on the basic types, plus buying tips

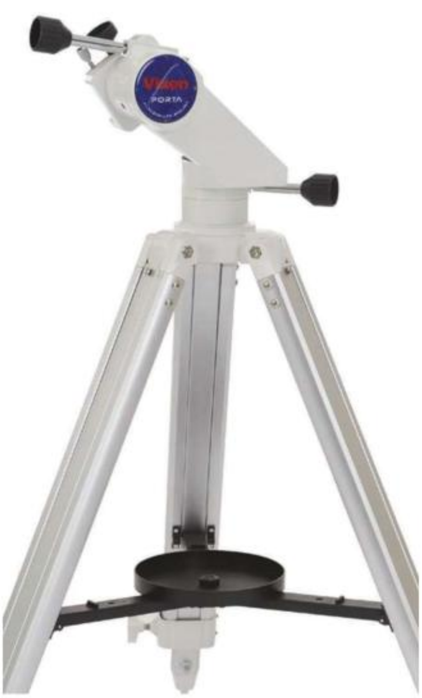


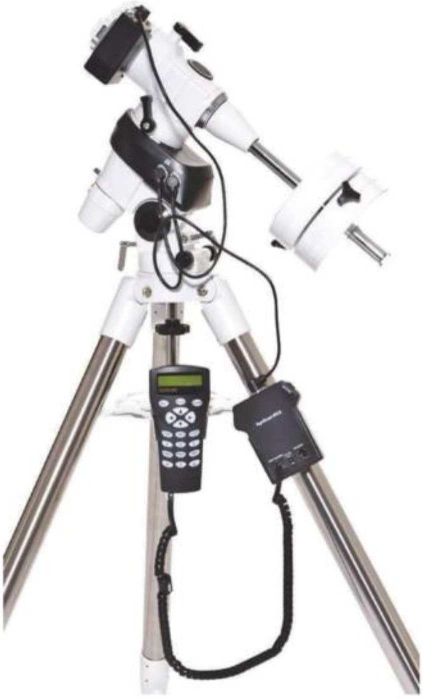
Once you've held even a small telescope for any length of time, you'll quickly realise that this is a weighty piece of kit that needs something to support it. This essential piece of any setup is called a mount. There are several basic types; which one is best for you, and how much it will cost, depends on what you want to use your telescope for.

Most mounts are a variant of two basic designs, altazimuth (altaz) and equatorial. Altaz mounts move in two axes, one perpendicular to the horizon (altitude, giving an up and down motion) and the other parallel to it (azimuth, giving a left and right motion), but most basic designs cannot track the night sky.

In equatorial mounts, one of the axes is parallel to the axis of Earth's rotation, meaning they can track the night sky and keep targets centred in the field of view – provided they are properly polar aligned before use. This makes them ideal for longer periods of observation or for long-exposure astrophotography.

If you'd like a permanent setup, then a heavy-duty mount with excellent tracking would be ideal. A lightweight but robust mount could be a better choice if space is limited or you need to set up quickly.





ISTOCK, PAUL WHITFIELD X 5, WWW.SECRETSTUDIO.NET

CAMERA TRACKING MOUNT

These mounts attach to a standard tripod. The hinge is angled towards the celestial pole, which allows for tracking with a camera as long as a polar alignment is performed during set up. Many camera tracking mounts can even support small telescopes, making them useful if you want a portable setup.

ALTAZIMUTH (ALTAZ) MOUNT

The humble tripod is the simplest form of altaz mount. It's easily portable and comes in models ranging from lightweight to sturdy, the latter being more than capable of holding a small refractor or small compound telescope. You can also buy dual-mounting manually operated altaz tripod mounts.

GERMAN EQUATORIAL MOUNT

Featuring one axis parallel to our planet's rotational axis, this mount design allows for the tracking of the stars as Earth turns. With a variety of carrying capacities – from non-motorised mounts up to heavy-duty tracking systems suitable for an observatory, this is an extremely popular mount.

DOBSONIAN MOUNT

Devised by renowned amateur John Dobson, the Dobsonian is a simple rocker box that supports a large Newtonian reflector on a turntable made from basic materials. The design is an easy to use, manually operated altaz system, although there are now some computerised models that can track the sky.

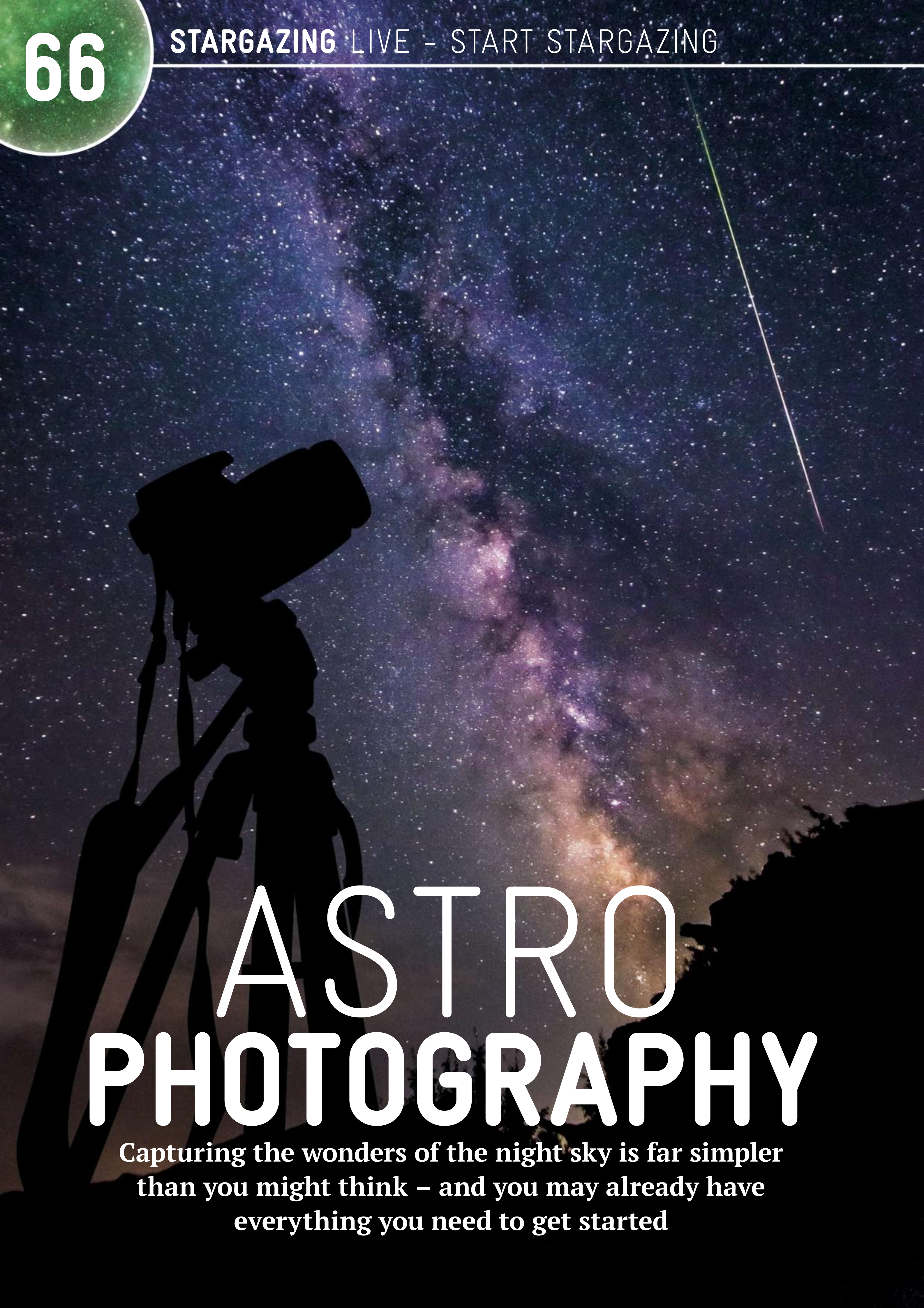
FORK MOUNT

Fork mounts are typically altaz, though they can be converted to equatorial using an equatorial wedge. Motorised or computerised fork mounts can move the telescope through the southern meridian without a meridian flip (the adjustment needed when the bottom of the telescope's tube bumps into the tripod leg when tracking an object all the way across the sky). This allows for imaging sessions across the meridian, which is a problem for German equatorial mounts.

EASY TRACKING

The system that allows you to find and follow with ease

A computerised setup, the Go-To features a handset which can smoothly control the mount and point it at a huge database of celestial objects, once an initial star alignment routine has been performed. Go-To systems take the hassle out of manually trying to find an object, especially if it is faint, and eliminate the need for printed star charts. Their databases usually include the Messier and NGC catalogues and the major planetary bodies. This opens up the night sky to novice stargazers and allows experienced astronomers to quickly locate and track deep-sky objects for astrophotography. Go-To technology is available on German equatorial and both large and small fork mounts; it can even be found on some altaz systems, including Dobsonians.



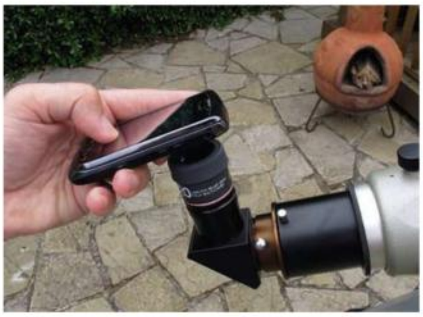
ASTRO PHOTOGRAPHY

Capturing the wonders of the night sky is far simpler than you might think – and you may already have everything you need to get started

Photographing the night sky is a wonderful way to make a lasting record of the many marvels you are lucky enough to see. Thanks to advances in digital cameras it's also never been easier, or more affordable. The great thing is, you don't need expert equipment, or even a standalone camera – your smartphone's camera should be capable of taking a decent photo of the Moon through a telescope eyepiece.

You also don't need to wait for the sky to become completely dark. The Moon, the bright planets and noctilucent clouds can all be seen in twilight skies.

The most versatile camera for new astro imagers is the DSLR, which can take wide-field shots of the sky while mounted on a tripod or attached to a telescope using an adaptor. They have features useful for astrophotography, including wide ISO ranges (your camera's sensitivity to light), interchangeable lenses and a bulb setting that allows you to hold the shutter open for as long as you want. DSLRs are self-contained, portable and can show you an image as soon as you've taken it, so you can adjust your settings to get the shot just right.



⮝ Afocal photography is one of the simplest methods of astrophotography; simply hold your camera to the eyepiece

⮝ A shutter release cable can operate your shutter remotely, avoiding any movement as you press the button

When taking photos with a DSLR in low light, your camera's shutter will need to stay open for longer than it does in the daytime to gather the light it requires. This can be several seconds so you will need a steady tripod.

DO AWAY WITH WOBBLE

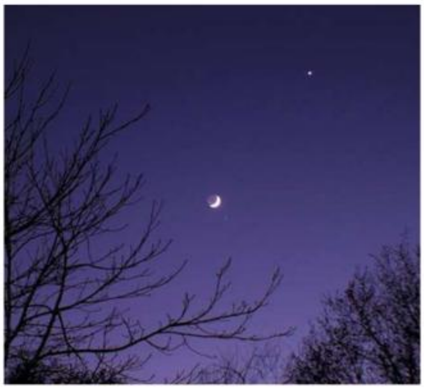
Another useful piece of kit is a shutter release cable. This allows you to operate the shutter remotely and take a picture without causing any wobble as you press the capture button down. Alternatively, use the camera's time-delay feature.

Prosumer and compact cameras have come a long way in recent years and provided they allow you to change their settings they can take good quality photos. There are also specialist cameras – high frame rate and cooled CCD devices, which take outstanding planetary and deep-sky imaging respectively – but they are not really designed for beginners.

If you already own a small telescope you can also try the simplest imaging technique: afocal imaging. This is the technical name for simply pointing your camera down the eyepiece of your scope. You can do this with a DSLR, a point and shoot, or even a smartphone. The hardest thing is keeping your hands steady as you hold your camera in line with the eyepiece.

HOW TO GET STARTED

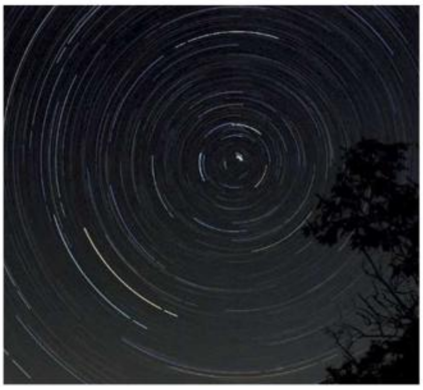
These three easy projects will help you learn the basics of astrophotography



PROJECT 1:

TWILIGHT SCENE

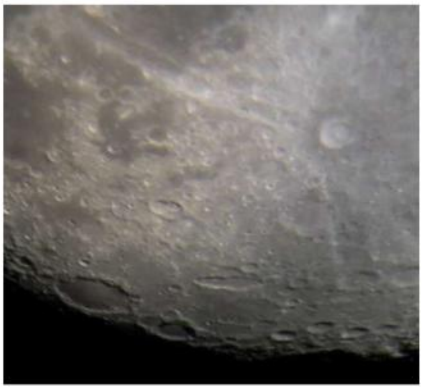
Look for a composition that includes a twilight sky, a low crescent Moon, maybe a planet or two and some trees or buildings that will silhouette themselves against the sky. If you have a DSLR, set it to manual mode. Fix it to your tripod and open the camera's lens as wide as it will go. Turn off the autofocus, as the low light will cause it to hunt back and forth, then manually focus at infinity and use different exposure times.



PROJECT 2:

STAR TRAILS

The idea for this shot is to capture the movement of the stars over time, showing the Earth is spinning. As well as a tripod-mounted camera, you'll need a remote shutter release cable. The camera has to be focused on the night sky for a long time to show this movement – exposures can be anything from 15 minutes to a few hours. Be sure to include Polaris, as the stars will appear to rotate around it.



PROJECT 3:

AFOCAL PHOTOGRAPHY

This project requires a telescope, but any camera will do – even a smartphone. Focus your telescope on the Moon, then hold the camera up to the eyepiece and take a few shots. Getting the right angle between the camera and the eyepiece, then holding the camera still, are the trickiest techniques to master. A live view screen which allows your camera's display screen to be used as a viewfinder will make this a bit easier.

ISTOCK X 5, PETE LAWRENCE, STEVE MARSH

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GET OUT STARGAZING

The best astronomical sights to see this spring and how you can observe them

WILL GATER, ISTOCK X 2

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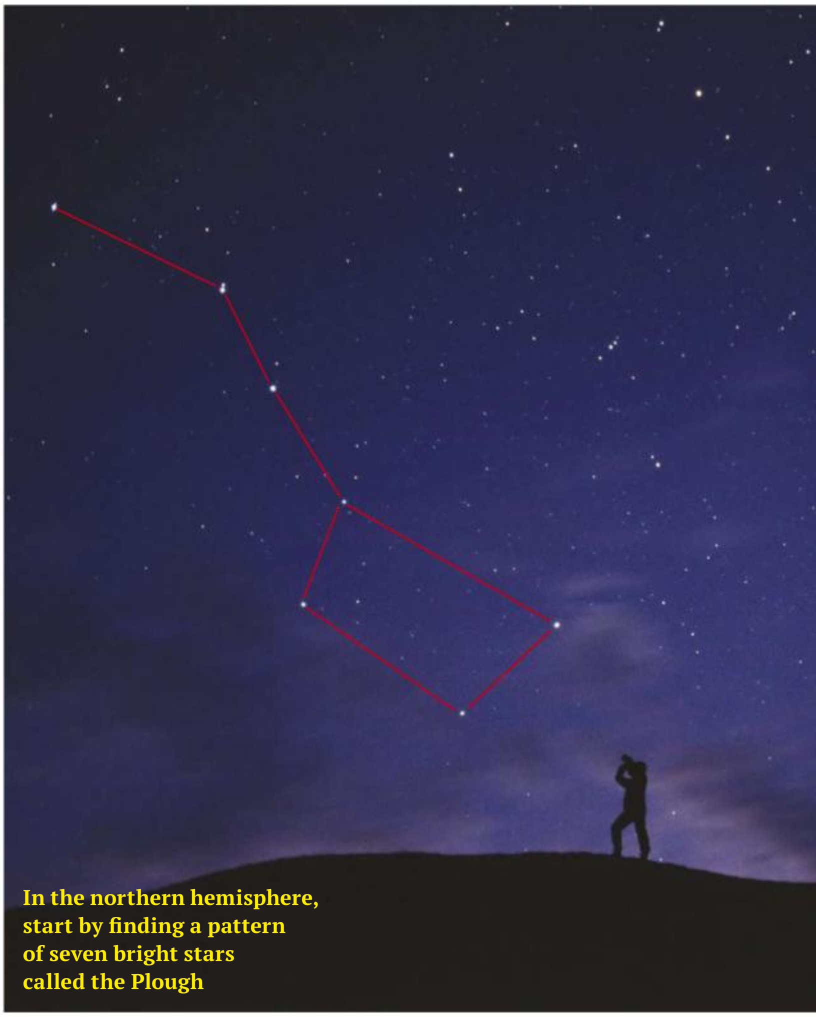
Your first task is to find some dark skies, as this will make identifying your first stars much easier



In the northern hemisphere, start by finding a pattern of seven bright stars called the Plough

YOUR FIRST NIGHT STARGAZING

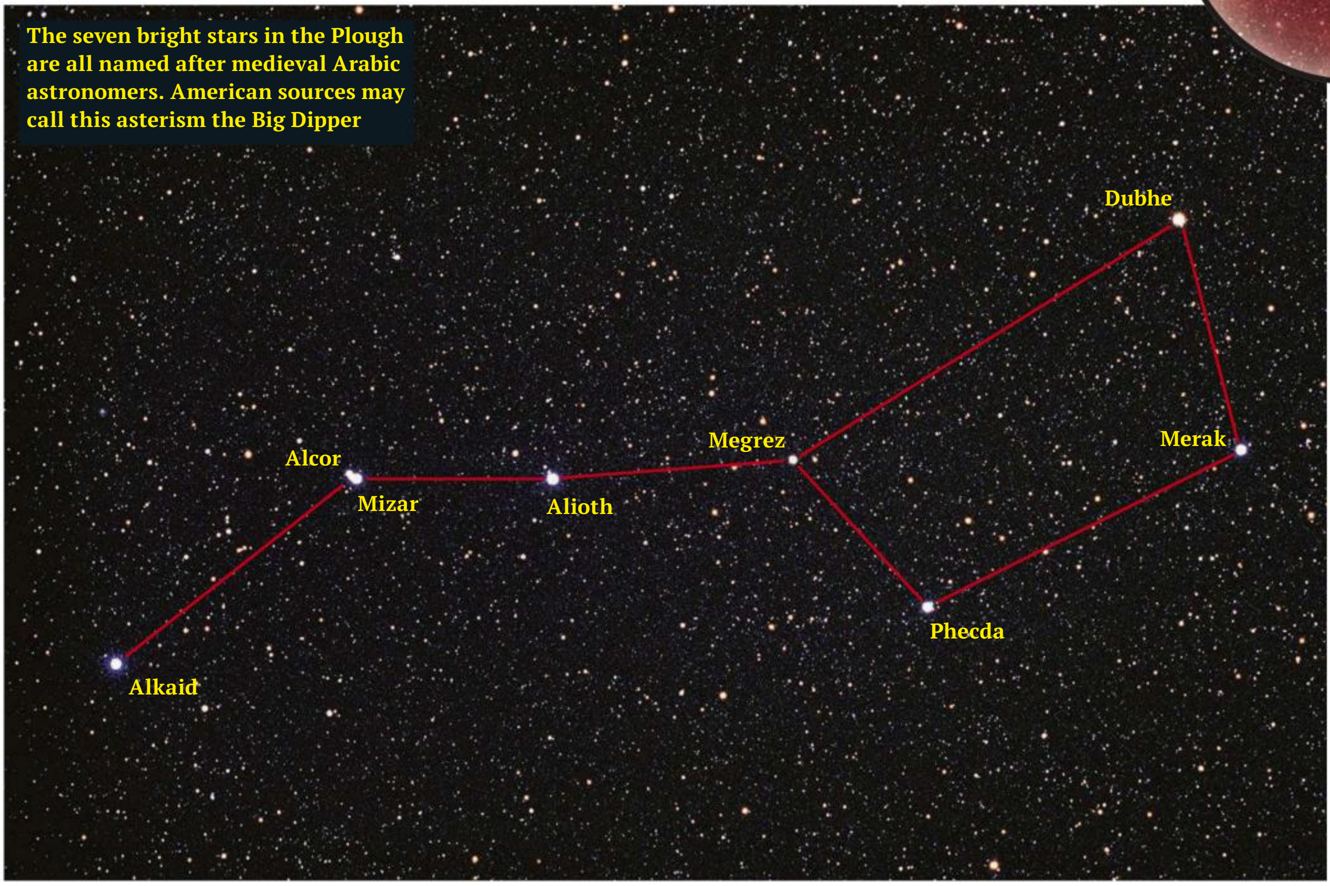
Start your exploration of the night sky by finding the Plough asterism and using it to locate Polaris, the Pole Star

STEVE MARSH X 3, PETE LAWRENCE, THINKSTOCK, PAUL WHITFIELD

It's your first night outside, you've found a nice, dark spot and you're gazing up at a sky peppered with pinpricks of light – so where do you begin? Starting out on your astronomical adventure can be as mystifying as it is exciting, but assuming you live in the northern hemisphere at a mid-to-high latitude, your first goal is to find the group of seven stars known as the Plough.

The Plough is an asterism – a pattern of stars – within the constellation of Ursa Major (the Great Bear). It happens to look like a saucepan and it marks the bear's tail and back.

The reason we're starting at the Plough is not only because this asterism is bright and easy to find, but because we have to take into account the rotation of the Earth. Just as the Sun appears to rise, move over the sky and set, so many of the stars appear to do the same thing at night – though not all. From UK latitudes some stars remain above the horizon all night long, including those in the Plough. As the Earth itself moves around the Sun we also see a slight shifting of stars night by night, which means some constellations enter and leave our skies over the course of a year. Again, the Plough is a constant presence, visible throughout the year. This makes the Plough a very useful pattern to learn and an excellent


The seven bright stars in the Plough are all named after medieval Arabic astronomers. American sources may call this asterism the Big Dipper

The star trails of a long-exposure photograph centred on Polaris show the Earth's rotation

place from which to launch your stargazing journey.

The Plough can be found in the northern part of the sky, so to locate it you'll need to know which way north is. You could use the Sun to guide you: north will be to the left of where the Sun rises, or to the right of where the Sun sets. The highest the Sun gets in any day is due south, so north is opposite to this. Alternatively, use a compass or one of the free compass apps on your smartphone.

SEVEN STARS

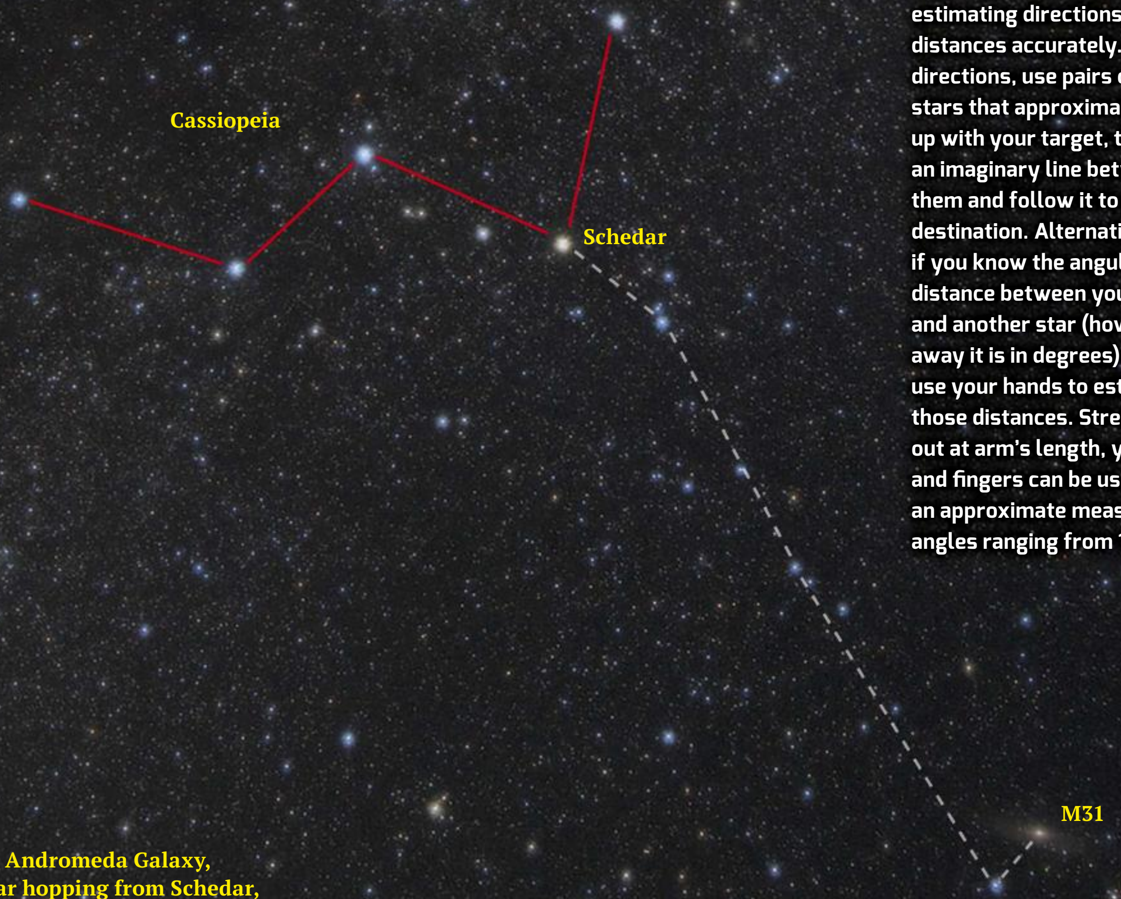
The Plough is unusual in that each of its seven stars has a name; not all stars do. It's helpful to learn the names and positions of these stars as you can use them as markers to find other objects in the night sky. We're going to begin with the star at the crook of the Plough's handle: Mizar. It has a companion that's not quite as bright and together they form a well-known double star that is visible to the naked eye. Look above and left of Mizar, at a distance of about one-third of the diameter of the Moon, and you should be able to spot its companion, Alcor.

Both Mizar and Alcor are white stars, but on the other side of the Plough you will find your first coloured star. The top-right star of the Plough's bowl has a slight orangey-yellow hue – Dubhe, the brightest star in the asterism. The best way of seeing this is to compare it with the star below it – the pure white Merak.

These two stars, known as the Pointers, are two of the most useful in the night sky because they make it easy to locate the Pole Star – Polaris. Starting at Merak, draw an imaginary line through Dubhe and keep going. The next star of any note you come across is Polaris. Surprisingly, Polaris is just an ordinary-looking star; it's famous because it sits almost directly above Earth's north pole and so appears to stay virtually in the same place as our planet spins, with the rest of the night sky rotating around it. Once you have learned the Plough you're ready to set forth and discover more of the wonders of the night sky.

NAVIGATING THE SKIES

Finding your way around the heavens is easier than it first seems – the secret is a simple technique called star hopping



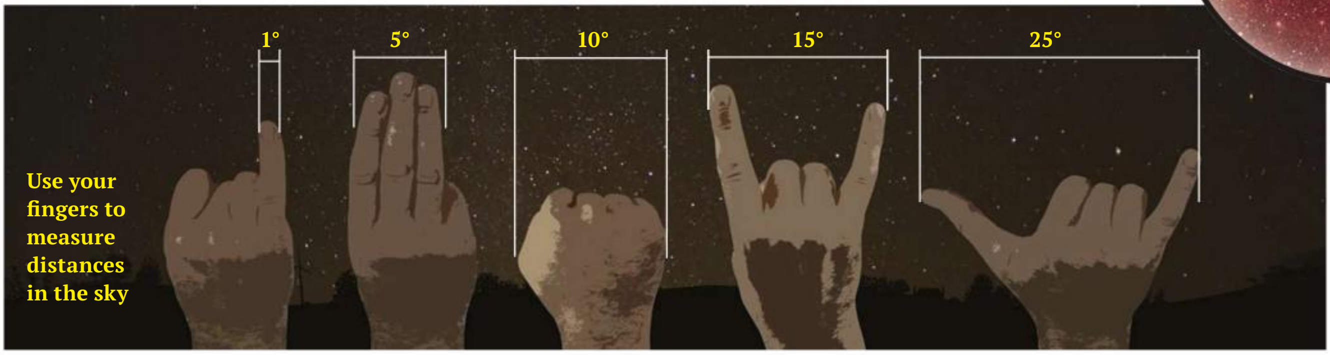
Locate the Andromeda Galaxy, M31, by star hopping from Schedar, one of the stars in the 'W' asterism in the constellation of Cassiopeia

Gazing up into the sky on a clear night, the profusion of stars and celestial objects above you can effect a common quandary: how will I ever find my way around this vast confusion of stars?

One option is to invest in a telescope with a 'Go-To' setup, a computerised system that controls the mount and can take you to any object in its database at the press of a button. But there is a simpler – and less pricey – solution: star hopping.

The brighter stars we can see from Earth form recognisable patterns – constellations, asterisms and even simple geometric shapes – and we can use these patterns as 'jumping off' points to less obvious and fainter regions or objects we'd like to explore.

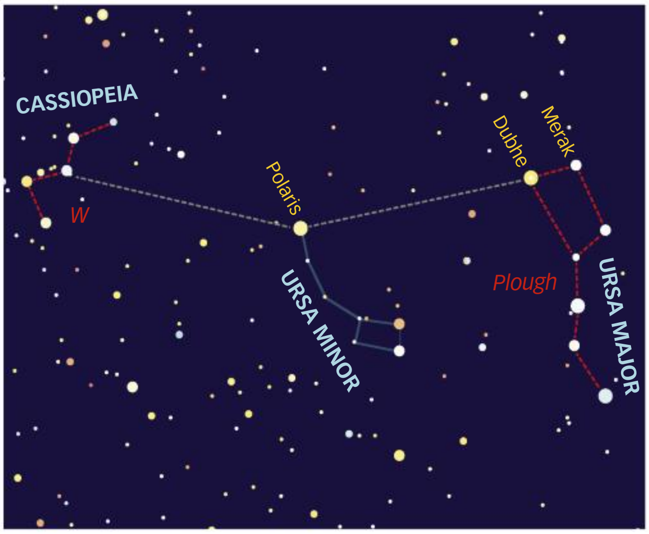
The most important skill when star hopping is estimating directions and distances accurately. For directions, use pairs of bright stars that approximately line up with your target, then draw an imaginary line between them and follow it to your destination. Alternatively, if you know the angular distance between your target and another star (how far away it is in degrees), you can use your hands to estimate those distances. Stretched out at arm's length, your hand and fingers can be used as an approximate measure of angles ranging from 1° to 25°.



Use your fingers to measure distances in the sky

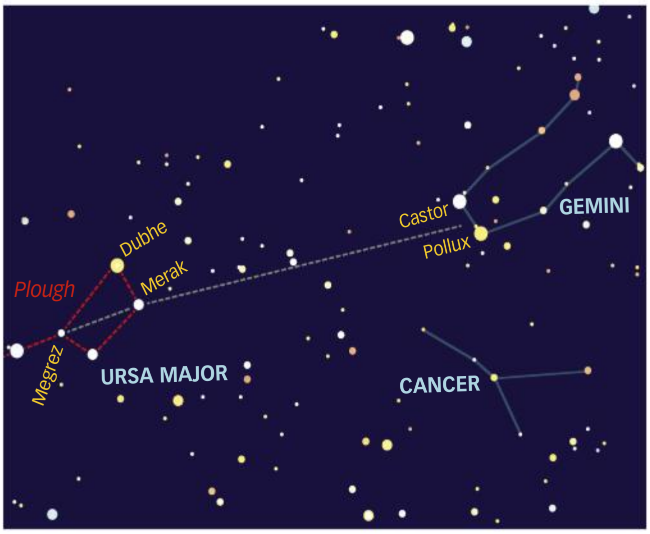
TEST YOUR STAR HOPPING SKILLS

Use the stars in the Plough asterism to find these four constellations



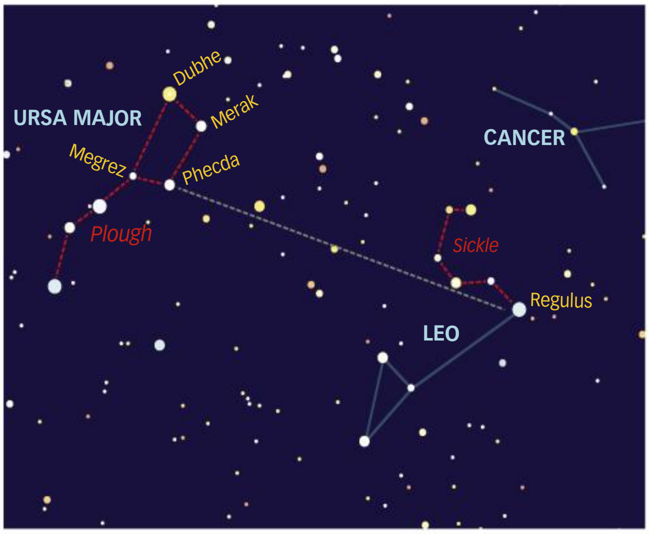
CASSIOPEIA – THE QUEEN

Locate Polaris (see page 70 for how to do this) then continue this imaginary line on for the same distance you've already come from the Plough, take a slight bend to the right, and you'll arrive at the 'W' asterism in the constellation of Cassiopeia.



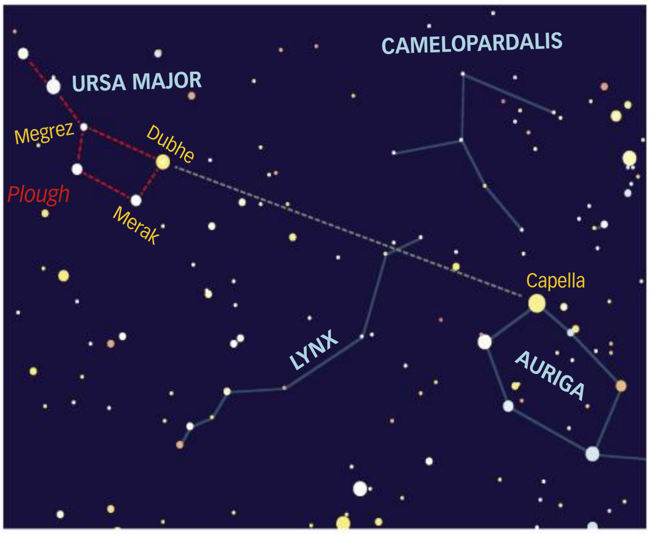
GEMINI – THE TWINS

To find Castor and nearby Pollux, the main stars of Gemini, start from the Plough star Megrez. Draw an imaginary line to Merak, diagonally opposite it, and keep going. Almost halfway to your target look out for the two stars that form the front paws of Ursa Major.



LEO – THE LION

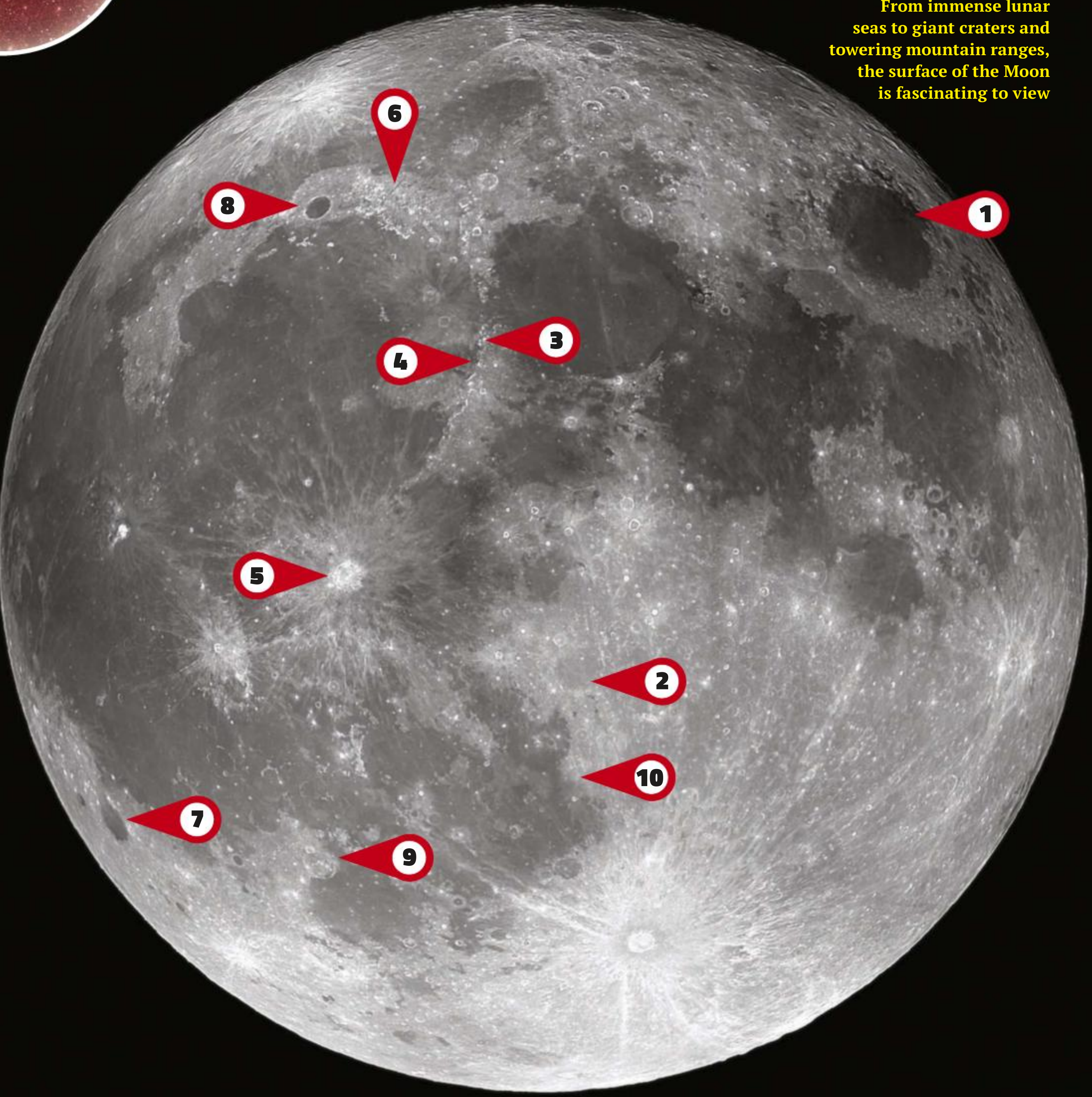
To locate Leo start from Megrez, this time imagining a line through Phecda, the star below it in the Plough. Continue on this line and you'll reach Regulus, the brightest star in Leo. The Lion's head is a hook-shaped asterism called the Sickle, with Regulus at its base.



AURIGA – THE CHARIOTEER

To hop to Auriga start from Megrez but take a route through Dubhe, to its right. Pass through an expanse of emptiness that includes the very faint constellation of Camelopardalis (the Giraffe) and you'll arrive at the yellow star Capella, the brightest star of Auriga.

BERNHARD HUBL/CCDGUIDE.COM, CHARTS: PETE LAWRENCE, ILLUSTRATION STEVE MARSH

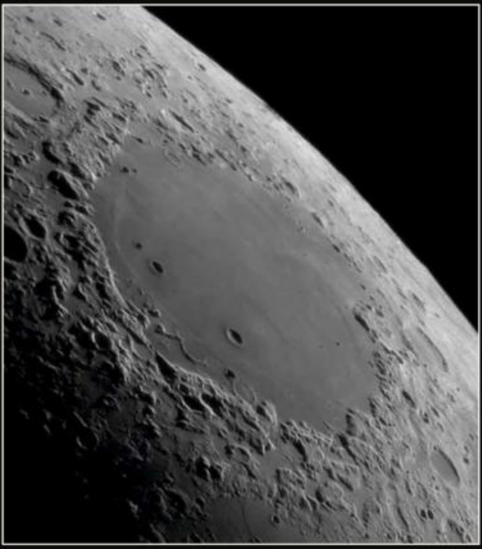


From immense lunar seas to giant craters and towering mountain ranges, the surface of the Moon is fascinating to view

MARVELS OF THE MOON

You don't have to look far to discover some glorious celestial spectacles – here are our top 10 Moon sights

STEVE MARSH X 3, PETE LAWRENCE, CHRISTIAN FRIEBER/CCDGUIDE.COM,
MICHAEL KARRER/CCDGUIDE.COM X 4, ROBERT SCHULZ/CCDGUIDE.COM,



1 MARE CRISIUM

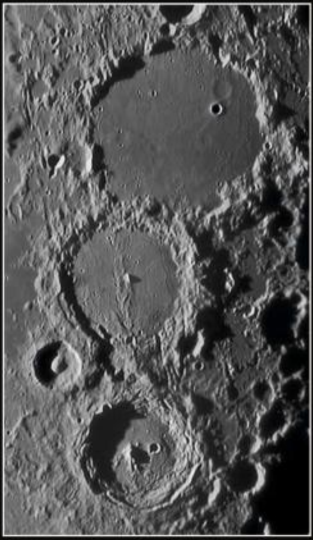
Equipment: Binoculars

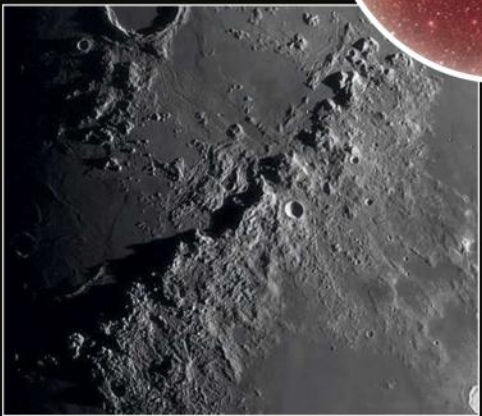
Located close to the eastern limb, this huge lunar ‘sea’ is one of the Moon’s most recognisable features. To the naked eye this large plain appears as a dark, oval patch and unlike the other seas it’s completely detached. The high boundary around its smooth-looking floor creates giant shadows as the terminator (the demarcating line separating lunar day and night) crosses the sea.

2 CRATERS PTOLEMAEUS, ALPHONSUS & ARZACHEL

Equipment: Small scope

These three striking craters sit close to the centre of the Moon’s near side. Look closely and you’ll see that the largest of them, Ptolemaeus, has a smooth floor that is pitted with lots more tiny craters.

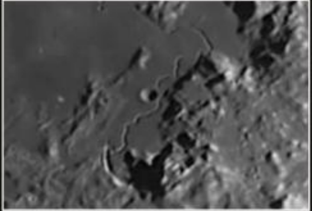




3 THE LUNAR APENNINES

Equipment: Small scope

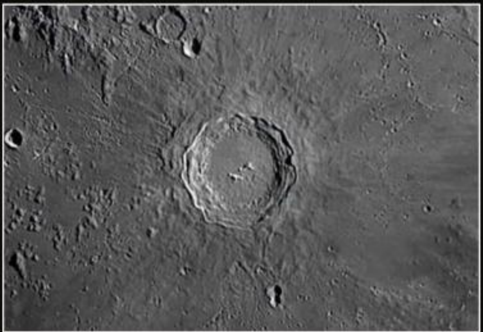
The Apennines mountain range extends over 900km across the Moon’s surface. It is particularly dramatic when lit from the side – when the high peaks cast large, inky black shadows onto the surrounding landscape.



4 HADLEY RILLE

Equipment: Large scope

Famous as one of the features explored by the Apollo 15 astronauts, Hadley Rille, a deep channel, is a fascinating target to look at with a large telescope. With the right light it appears as a narrow, meandering black line near the northern end of the lunar Apennines.



5 CRATER COPERNICUS

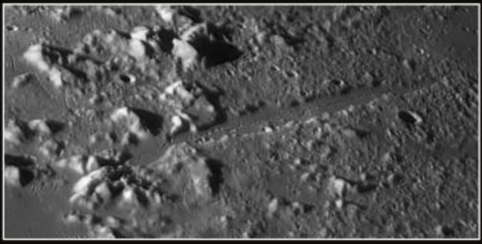
Equipment: Small scope

This 93km-wide crater has a distinctive terraced rim. It sits at the centre of a huge system of bright rays that spread out for hundreds of kilometres.

6 THE VALLIS ALPES

Equipment: Small scope

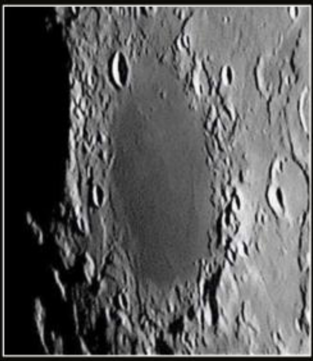
Cutting through the lunar Alps, this 130km-long valley is one of the most interesting features on the Moon’s surface. Vallis Alpes can be spotted with even a small telescope.

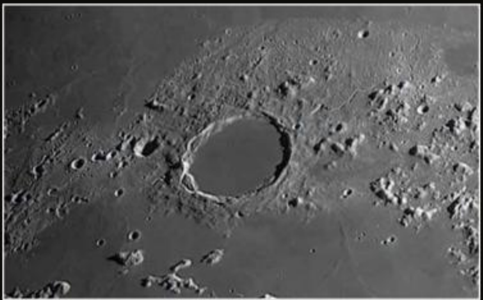


7 CRATER GRIMALDI

Equipment: Binoculars

This dark, 173km-wide basin is visible to the naked eye, but reveals lots of detail through binoculars and telescopes, including eroded walls, ridges and low hills.

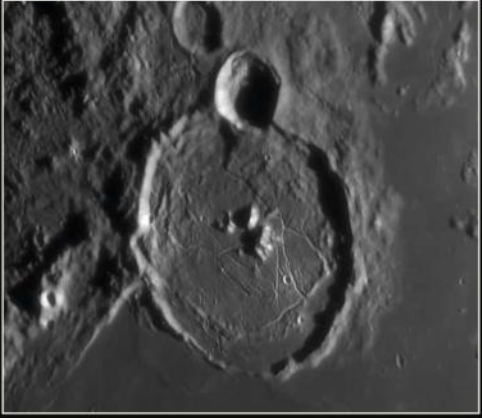




8 CRATER PLATO

Equipment: Small scope

This enormous, 109km-wide crater lies within the jagged landscape near the northern edge of the Mare Imbrium. It has a smooth floor and is surrounded by interesting features, including Rima Plato and the Montes Teneriffe.



9 CRATER GASSENDI

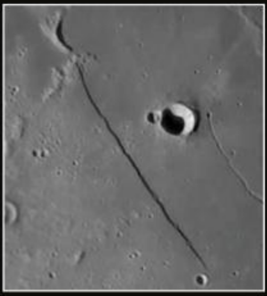
Equipment: Small scope

This intriguing, 110km-wide crater sits on the northern edge of the Mare Humorum. Under the right light, you can see a splendid network of rilles on its floor.

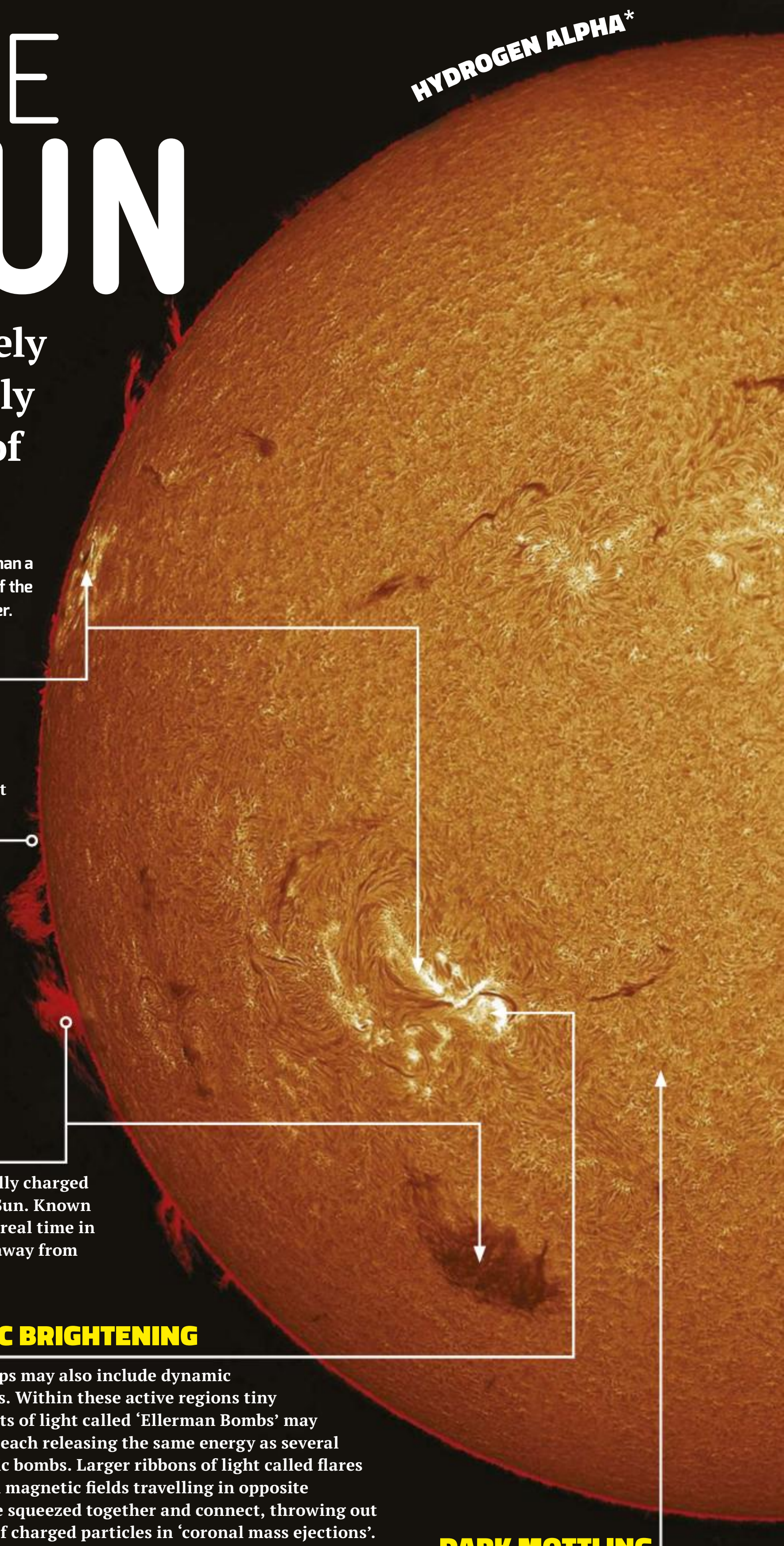
10 RUPES RECTA

Equipment: Small scope

Best known as the Straight Wall, look for a thin black line near to crater Birt. This 110km-long fault towers over 270m above the lunar surface.



HOW TO OBSERVE THE SUN



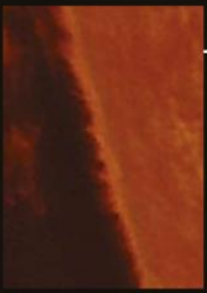
WARNING
Do not look directly at the Sun with the naked eye or any unfiltered optical instruments

It's possible to safely view the incredibly dynamic nature of our nearest star

*A hydrogen-alpha filter makes the Sun's disc appear slightly larger than a white light one because it reveals the chromosphere, which sits on top of the photosphere. Only the photosphere is visible through a white light filter.

ACTIVE REGIONS

Sunspot groups, or active regions, appear quite different when observed with a hydrogen-alpha filter*. Dark sunspots become trickier to see, partially hidden under the surrounding chromosphere. Around them, dark fibrils (mottles) follow the intense magnetic fields associated with these regions. Big, bright areas called 'plage' appear within and around sunspot groups.

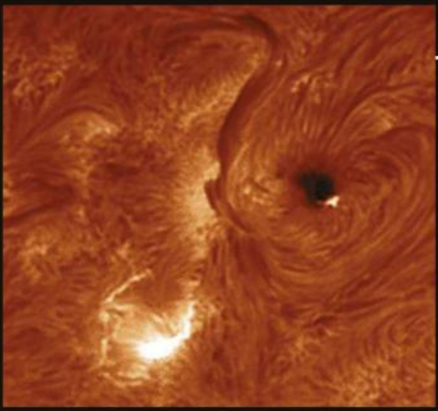


SPICULES

The thin 'skin' that seems to run around the edge of the Sun's disc is a cross-section of the chromosphere, the second of the three main layers in the Sun's atmosphere. Under good seeing you can discern that it's made up of jets of gas known as 'spicules'. Together they make the edge, or 'limb', of the Sun appear 'furry'.

PROMINENCES AND FILAMENTS

Viewed with a hydrogen-alpha filter*, huge clouds of magnetically charged hydrogen plasma can often be seen hanging off the edge of the Sun. Known as 'prominences', these can change appearance day-to-day or in real time in extreme circumstances. When seen against the chromosphere, away from the Sun's edge, they appear dark and are known as 'filaments'.



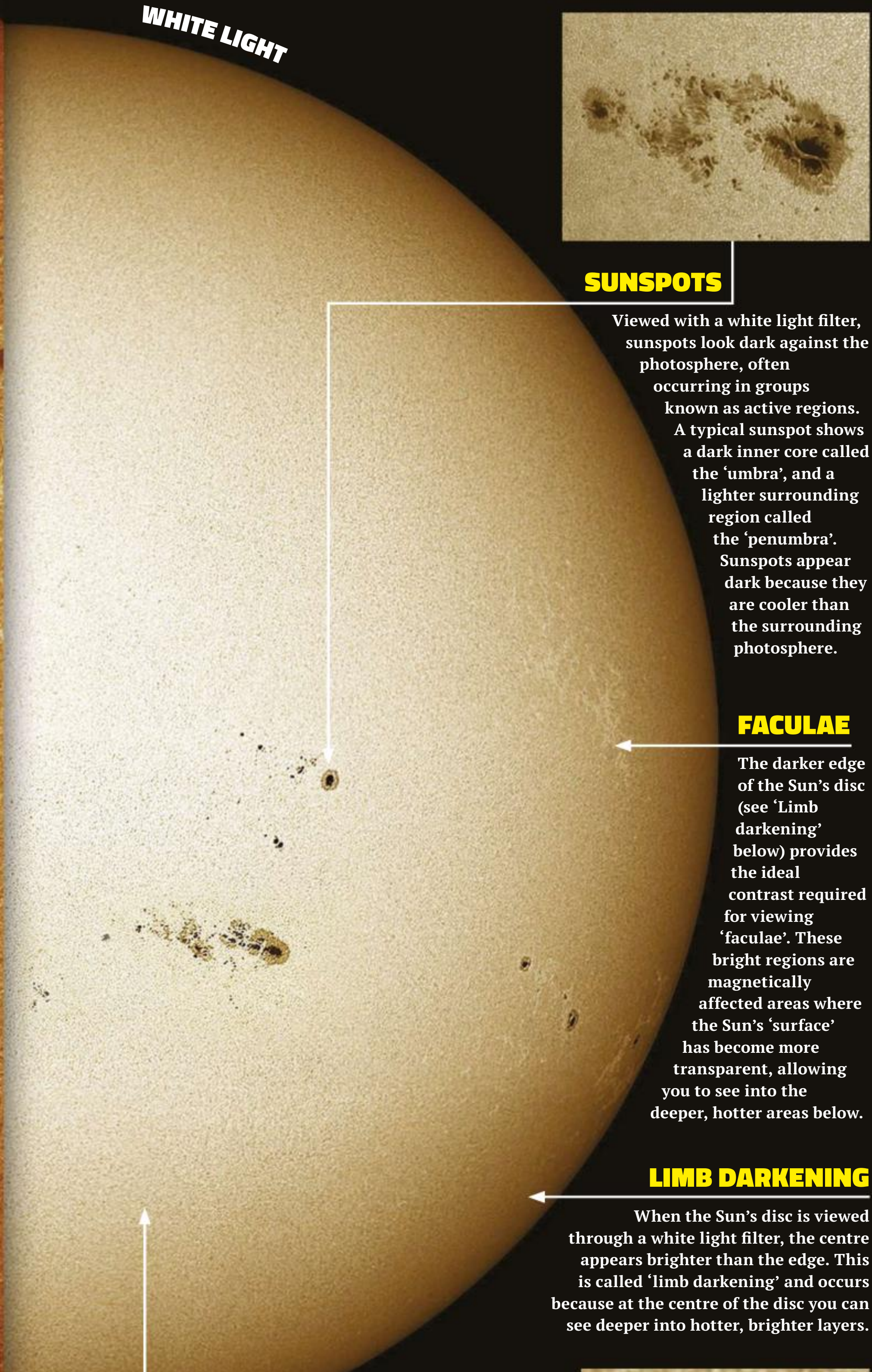
DYNAMIC BRIGHTENING

Sunspot groups may also include dynamic bright regions. Within these active regions tiny star-like points of light called 'Ellerman Bombs' may come and go, each releasing the same energy as several million atomic bombs. Larger ribbons of light called flares develop when magnetic fields travelling in opposite directions are squeezed together and connect, throwing out huge clouds of charged particles in 'coronal mass ejections'.

DARK MOTTLING

When the chromosphere is observed with a hydrogen-alpha filter* you'll see that it's covered in a coarse, light and dark pattern known as 'dark mottling'. This magnetically-influenced pattern is visible across the entire disc and makes the Sun resemble a giant orange.

ALL PICTURES: PETE LAWRENCE



SUNSPOTS

Viewed with a white light filter, sunspots look dark against the photosphere, often occurring in groups known as active regions. A typical sunspot shows a dark inner core called the 'umbra', and a lighter surrounding region called the 'penumbra'. Sunspots appear dark because they are cooler than the surrounding photosphere.

FACULAE

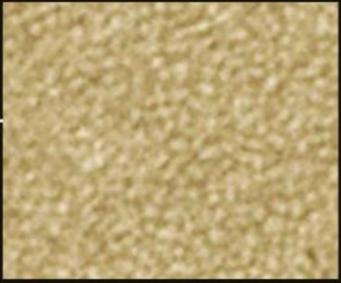
The darker edge of the Sun's disc (see 'Limb darkening' below) provides the ideal contrast required for viewing 'faculae'. These bright regions are magnetically affected areas where the Sun's 'surface' has become more transparent, allowing you to see into the deeper, hotter areas below.

LIMB DARKENING

When the Sun's disc is viewed through a white light filter, the centre appears brighter than the edge. This is called 'limb darkening' and occurs because at the centre of the disc you can see deeper into hotter, brighter layers.

GRANULATION

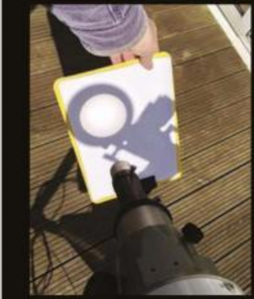
The Sun's visible surface, or photosphere, is covered in a fine pattern called solar granulation. This can be tricky to see and image as it's easily hidden by poor seeing. Caused by differences in density within the Sun, this pattern is created when hotter convection cells rise up and reach the photosphere.



SAFELY OBSERVE
THE SUN

From DIY to precision engineering, you can view the Sun without damaging your eyes

SOLAR PROJECTION

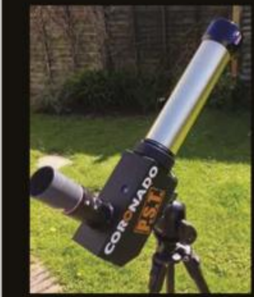


Solar projection is suitable for small refractor telescopes. The idea is to point the scope at the Sun and place a screen, typically a piece of white card, behind the telescope's eyepiece. This method can show solar granulation, dark sunspots and bright faculae.

WHITE LIGHT SOLAR FILTER

A sheet of white light solar safety material can easily be turned into an inexpensive filter for use with any type or size of amateur telescope. It's available in A4 sheets and allows you to view and image granulation, sunspot groups and faculae.

SPECIALIST SCOPES



An entry level hydrogen-alpha* scope, such as the Coronado PST, costs upwards from £700. This instrument is able to show prominences, dark mottles, filaments and many of the bright phenomena associated with active regions, such as plage and flares.

SUPERIOR SCOPES AND FILTERS

Finer detail, larger aperture, narrower bandwidth hydrogen-alpha telescopes are also available, typically for several thousand to tens of thousands of pounds. Solar hydrogen-alpha filter* kits in a similar price range can also be used to convert night-time telescopes (pictured here).

HIGHLIGHTS OF THE DEEP SKY

Discover some of the best targets in the deep sky and the equipment you'll need to find them

GALAXIES

Bound together by gravity, these systems contain millions or billions of stars

The Andromeda Galaxy, M31
Constellation: Andromeda
The spectacular Andromeda Galaxy is the nearest large galaxy to the Milky Way and under dark, Moon-free skies you can see it with the naked eye. Look for this spiral galaxy as a faint, misty patch a short distance from the band of the Milky Way. Using binoculars, you'll find it with little or no difficulty. It'll be oval in appearance – although with binoculars you won't be able to distinguish any of the individual stars within it. Through a 6-inch telescope the galaxy appears as a larger, elongated oval with a slightly brighter core. In 4.5 billion years the Andromeda is expected to collide with the Milky Way to form one giant galaxy.

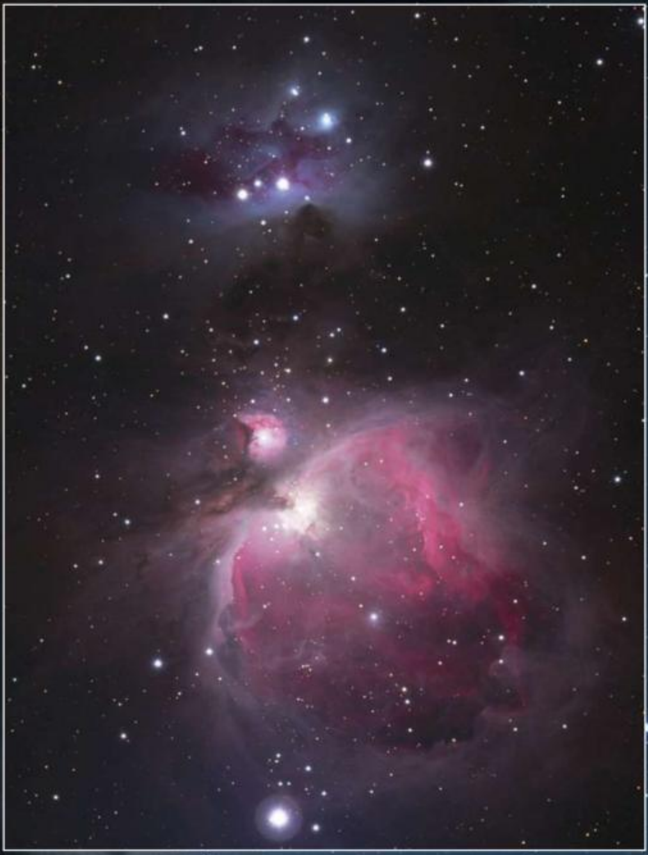
The Triangulum Galaxy, M33
Constellation: Triangulum
To observe M33 with the naked eye, you'll need pristine dark skies. If there's any light pollution, you'll want a pair of binoculars to hand. The Triangulum Galaxy sits between mag. +2.2 Hamal (Alpha (α) Arietis) and mag. +2.1 Mirach (Beta (β) Andromedae).

The Pinwheel Galaxy, M101
Constellation: Ursa Major
This is a face-on spiral galaxy of a similar size to the Milky Way. It can be viewed in binoculars but its magnitude of +7.9 means you'll need dark skies and a 6-inch telescope to see its spiral arms.

CHRISTOPH KALTSEIS/CCDGUIDE.COM X 2, HORST ZIEGLER/CCDGUIDE.COM, BERNHARD HUBL/CCDGUIDE.COM X 5, ISTOCK X 2

NEBULAE

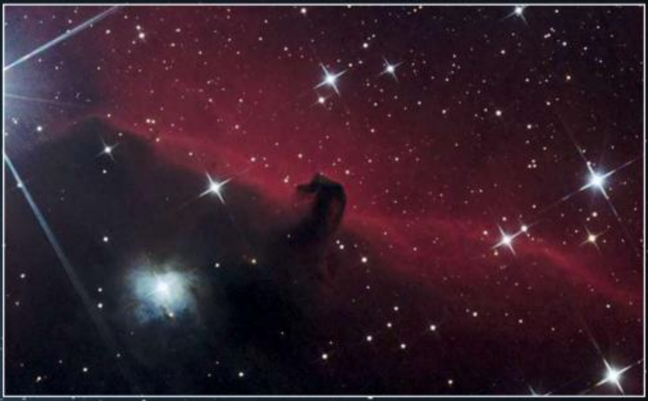
Some of these clouds of gas and dust glow on their own; some reflect nearby starlight



The Orion Nebula, M42

Constellation: Orion

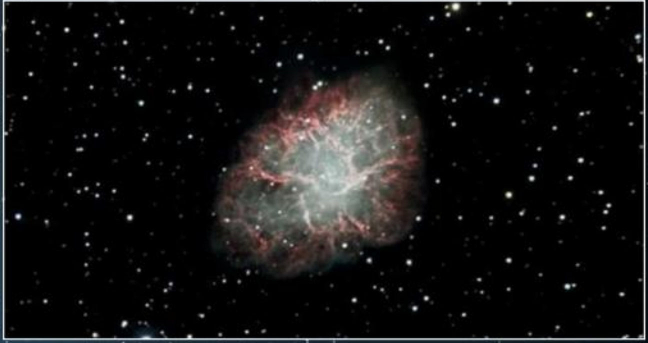
The only nebula that can be seen with the naked eye, M42 is the brightest in the night sky. You'll need a dark sky free from light pollution, then look below the three stars of Orion's belt and you'll see this emission nebula as a small, misty smudge. Binoculars will begin to reveal its curving shape. With a small telescope, you'll start to see some structure. Four stars at the heart of M42 energise the entire nebula with their radiation, causing it to glow.



The Horsehead Nebula, Barnard 33

Constellation: Orion

The Horsehead Nebula sits south of Orion's Belt in the Orion Molecular Cloud Complex. It's a dark nebula that appears silhouetted against a brighter background of nebulosity. You'll need a large aperture telescope and dark skies to observe it.



The Crab Nebula, M1

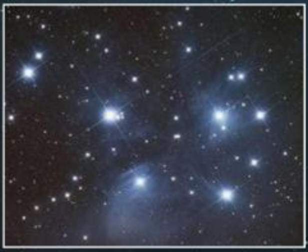
Constellation: Taurus

The stunning Crab Nebula is what remains of a cataclysmic stellar explosion seen from Earth in 1054. It can be spotted with a small telescope, but its fascinating vein-like texture is only revealed by a really large aperture instrument.

STAR CLUSTERS

Each of these glowing groups of stars formed in its own vast cloud of gas and dust

OPEN CLUSTERS



M45

Constellation: Taurus

It's easy to see six stars of the splendid Pleiades, or Seven Sisters, with the naked eye but counting up to 10 is possible. Decent binoculars will reveal the cluster actually contains many dozens of stars.

NGC 869 and NGC 884

Constellation: Perseus

This double cluster, the 'Sword Handle', is two star clusters side by side. Both are 0.5° in diameter and visible to the naked eye. Use binoculars to see hundreds of stars against the backdrop of the Milky Way.

GLOBULAR CLUSTERS

M5

Constellation: Serpens

Thought to be one of the oldest of all globular clusters, M5 is easily found in binoculars. It has a slightly oval-shaped appearance and the fuzzy blob you'll see hints at the huge quantity of stars it contains.

M22

Constellation: Sagittarius

One of the brightest globular clusters, M22 is easily visible with the naked eye. It's also a stunning sight through binoculars or a small scope, thanks to its location in the Milky Way's river of stars.

STARGAZING GUIDE APRIL

Mercury, the Moon and the Lyrid meteors are must-sees

KEY DATES

1 APRIL Twilight this evening is a good time to look for Mercury

3 APRIL Watch the Lunar X appear from 22:30 BST (21:30 UT)

7 APRIL Jupiter at its best and brightest; Ganymede and its shadow cross the planet between 19:30 and 21:55 BST (18:30 and 20:55 UT)

22 APRIL Peak activity for the Lyrid meteor shower

28 APRIL See the Moon move in front of bright star Aldebaran from 18:50 BST (17:50 UT)

The end of March sees spring equinox occur in the northern hemisphere. This time of year is when the Sun appears to be getting higher in the sky most rapidly. As a consequence the days get noticeably longer and the nights become shorter, particularly in April.

KEY SIGHTS TO SEE

Arcturus

First locate the Plough, which to modern eyes looks like a saucepan and is almost overhead during the early evening. Follow the handle away from the pan and keep its natural arc as you go. This will bring you to the bright orange star Arcturus, the alpha star of Boötes, the Herdsman. This constellation resembles a large kite with Arcturus at the sharp end. For scale, the kite is as high as the Plough is long.

Virgo

Continue the arc through Arcturus to eventually arrive at brilliant white Spica, the brightest star in Virgo, the Virgin. Virgo is a large and sprawling constellation. Its most distinctive pattern is an asterism known as the Bowl of Virgo, resembling a semi-circle of medium-bright stars. Currently, bright Jupiter can be seen south and slightly to the east of this bowl.

The Realm of Galaxies

Inside and to the north of the Bowl is a region of sky known as the Realm of Galaxies. A small telescope will show many examples of the hundreds of galaxies that litter this region. Move north of the Bowl and you will arrive at Coma Berenices, or Queen Berenice's hair, a faint constellation notable because part of it is made up of the triangular open cluster called Melotte 111. On a clear, dark night the cluster sparkles as its faint stars appear to jump in and out of view.

The Hunting Dogs

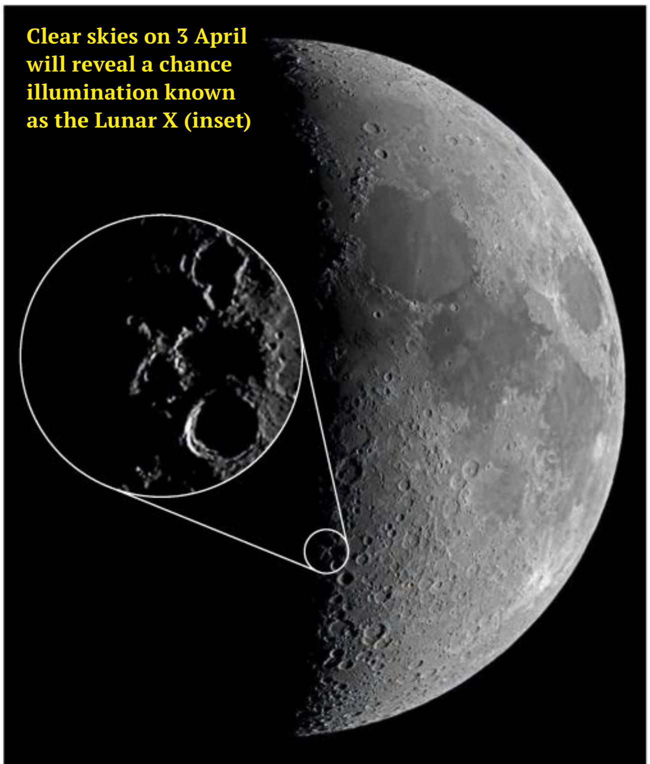
Between Coma Berenices and the Plough lies the small constellation of Canes Venatici, the Hunting Dogs. This constellation is represented by two main stars; Cor Caroli the alpha star and Chara the beta star. Despite its seemingly diminutive size, the boundaries of Canes Venatici contain some superb deep-sky objects. Here the list includes M51, the Whirlpool Galaxy, and the impressive globular cluster M3, which lies at the mid-point of a line drawn between Cor Caroli and Arcturus.

La Superba

Now imagine a line from Alpha (α) to Beta (β) Canum Venaticorum. Draw a similar length line at right-angles to this from Beta, towards the Plough. The end of this line will point at a star about as faint as you can see with your eyes from an average dark-sky site – Y Canum Venaticorum. Point a telescope at it to reveal its true beauty as a very red-coloured star. Its informal name is La Superba and when you see it through the eyepiece you'll realise why.

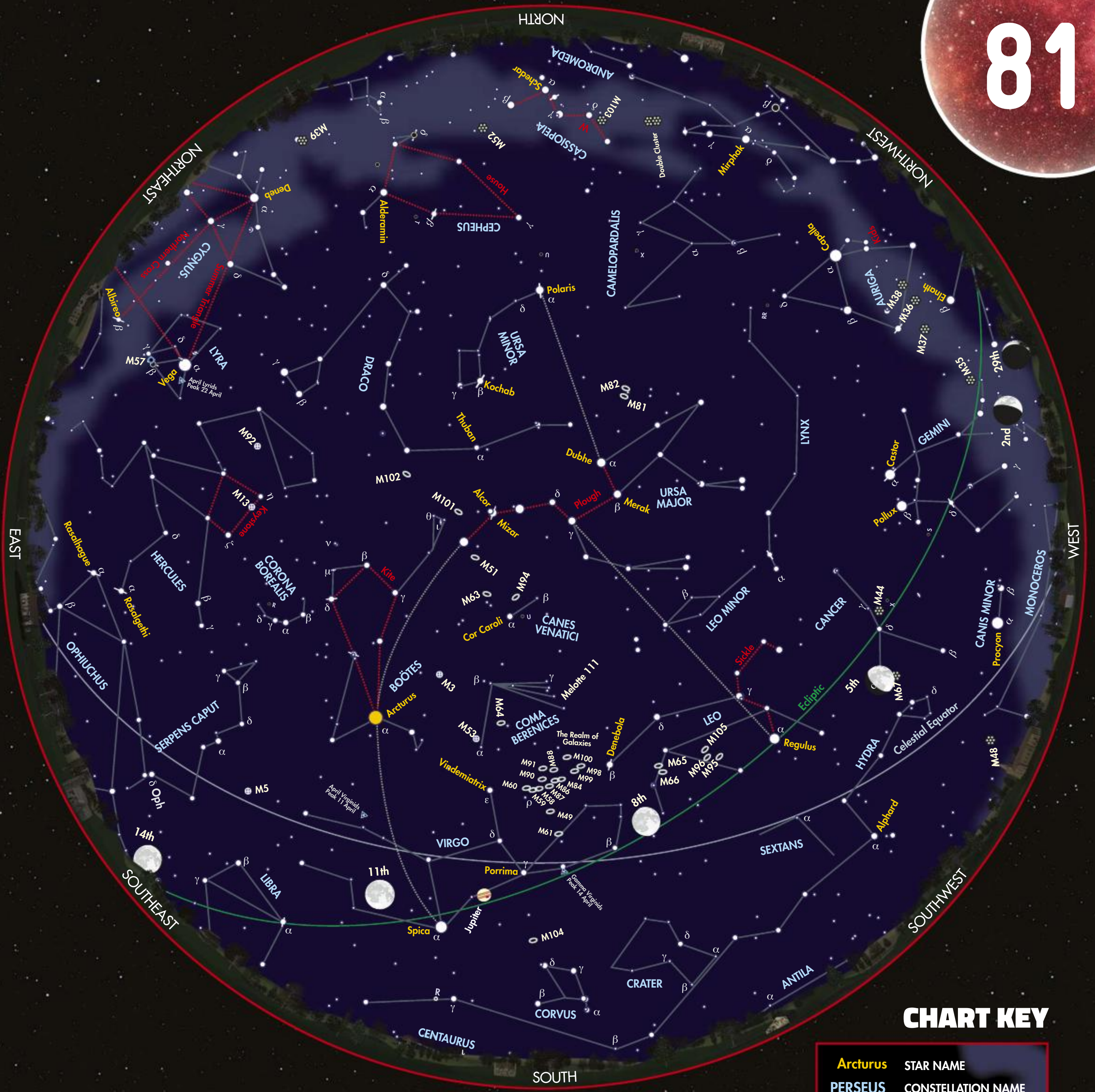
The Moon

If it's clear on 3 April around 22:30 BST (21:30 UT) take a look at the Moon's terminator (the demarcating line that separates lunar day and night), approximately one quarter of the way up the Moon's diameter from the south. What you're looking for is the 'Lunar X', a chance illumination that resembles the letter 'X'. Be quick though: it only appears for a short time!



Clear skies on 3 April will reveal a chance illumination known as the Lunar X (inset)

STEVE MARSH, CHART BY PETE LAWRENCE



MOON PHASES Key stages in the monthly cycle

FIRST QUARTER MOON
3 Apr

FULL MOON
11 Apr

LAST QUARTER MOON
19 Apr

NEW MOON
26 Apr

VISIBLE PLANETS Where to spot the planets this month

MERCURY
A well positioned evening planet furthest east from the Sun on 1 April. Invisible after 10 April

VENUS
A morning object best seen around 12 April

MARS
An evening planet, not especially well positioned

JUPITER
Reaches opposition on 7 April: best view of the year. Moon appears close on 10 April

SATURN
See it in the mornings in Sagittarius with the ring system nicely presented

URANUS
Moves behind the Sun on 14 April and not visible this month

NEPTUNE
Not visible this month

CHART KEY

Arcturus STAR NAME
PERSEUS CONSTELLATION NAME
GALAXY
OPEN CLUSTER
GLOBULAR CLUSTER
PLANETARY NEBULA
DIFFUSE NEBULOSITY
DOUBLE STAR
VARIABLE STAR
THE MOON (SHOWING PHASE)
COMET TRACK
ASTEROID TRACK
STAR-HOPPING PATH
METEOR RADIANT
Circlet ASTERISM
← MILKY WAY
PLANET
STAR BRIGHTNESS:
MAG. 0 & BRIGHTER
MAG. +1
MAG. +2
MAG. +3
MAG. +4 & FAINTER

BINOCULAR TOUR APRIL

Six top sights to see in April with 10x50 or 15x70 binoculars; from a globular cluster to a stellar chain

☑ Tick the box when you've seen each one

1 M92 15x70s

First on the tour is M92, a fine globular cluster that suffers from its proximity to a far more illustrious one. Start at the northwest corner of the Keystone asterism in Hercules and imagine a line heading northeast to mag. +3.8 Iota (ι) Herculis. Two thirds of the way along this line, M92 shines at mag. +6.4; with an apparent diameter of about one fifth of the Moon's. When you find it, you'll see the light of a third of a million stars.

☐ **SEEN IT**

2 M13 10x50s

M92's more renowned neighbour is M13, which is called the 'Great Cluster' for good reason. Situated a third of the way down the western side of the Keystone asterism, it is visible to the naked eye in a reasonably dark sky. Even with small binoculars, this mag. +5.8 globular cluster can be seen in urban skies, although it looks better in darker conditions. In 10x50s, it brightens in the centre. M13 contains over a million stars.

☐ **SEEN IT**

⮝ M92, the first of two globular clusters to be seen this month

3 NU CORONAE BOREALIS 10x50s

Line-of-sight double star Nu (ν) Coronae Borealis is an easy split in small binoculars, its distinct deep yellow components appearing a wide 6 arcminutes apart. The pair are remarkably similar: both are advanced giant stars with masses about 2.5 times that of the Sun. The more northerly star, n1, sits at 555 lightyears, just 10 lightyears farther away than n2. It is also a fraction brighter than its neighbour, shining at mag. +5.2, which is 0.2 magnitudes brighter than n2. This is a result of being about 750 million years more advanced in its evolution and therefore larger and more luminous.

☐ **SEEN IT**

4 TAU CORONAE BOREALIS 10x50s

Move 4° to the northwest of Nu Coranae Borealis and you'll come to mag. +4.7 Tau (τ) Coronae Borealis, the brightest in a very pretty straight chain (2.5° long) of five stars running east to west. All but the central star shine brighter than mag. +6.0. Notice that the mag. +5.6 stars at each end of the chain are a deeper yellow than the others, while the star next to the eastern end is almost white by comparison. The mag. +7.4 central star should easily resolve into a triple star under dark skies or with larger binoculars.

☐ **SEEN IT**

5 DELTA BOÖTIS 10x50s

Delta (δ) Boötis is another double star of mag. +3.5. The primary is a deep yellow giant star nearly 60 times more luminous than the Sun. Its yellow-white, mag. +7.8 companion appears to be 105 arcseconds away. Delta Boötis is 117 lightyears away and its components are moving through space together. This confirms that they are a binary star system: they have a separation of at least 0.6 lightyears and an orbital period of at least 120,000 years.

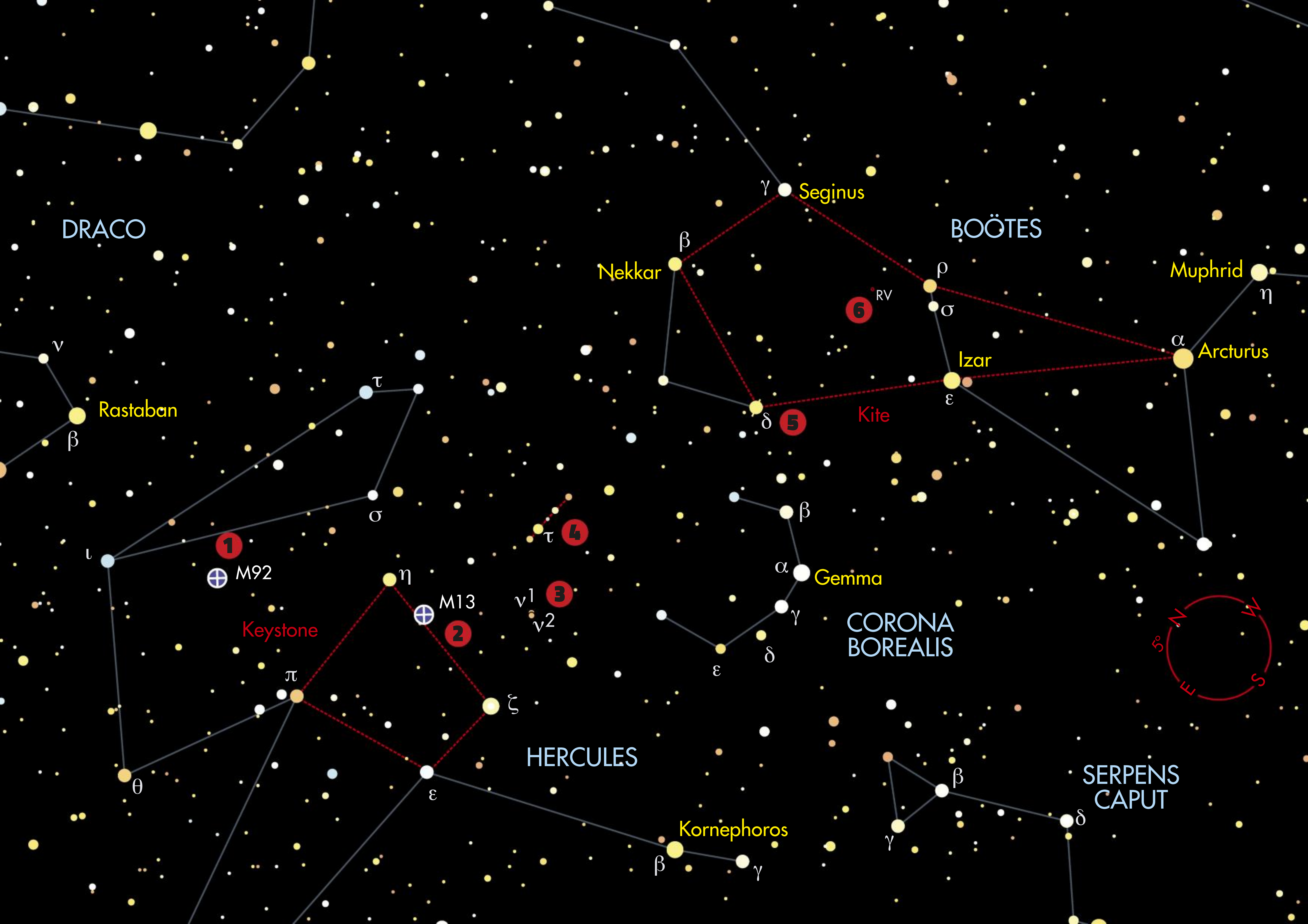
☐ **SEEN IT**

6 RV BOÖTIS 15x70s

RV Boötis (or HIP 71644) is a red star, in the later stage of evolution, and is a member of the giant branch of the stellar family. You can find it located 2.6° northeast of mag. +3.6 Rho (ρ) Boötis. RV is nearly midway between two mag. +6.3 stars, the brightest stars in the field of view of 15x70 binoculars. It is a semi-regular variable, which means that its brightness changes from mag. +7.2 to mag. +9.8 – although recently it has only been falling to mag. +8.8, so it remains well within reach of binoculars.

☐ **SEEN IT**

JON HICKS, DIETER BEER/PATRICK HOCHLEITNER/CCDGUIDE.COM, CHART: PETE LAWRENCE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STARGAZING GUIDE

MAY

Nights are shorter this month, but there's still plenty to see

KEY DATES

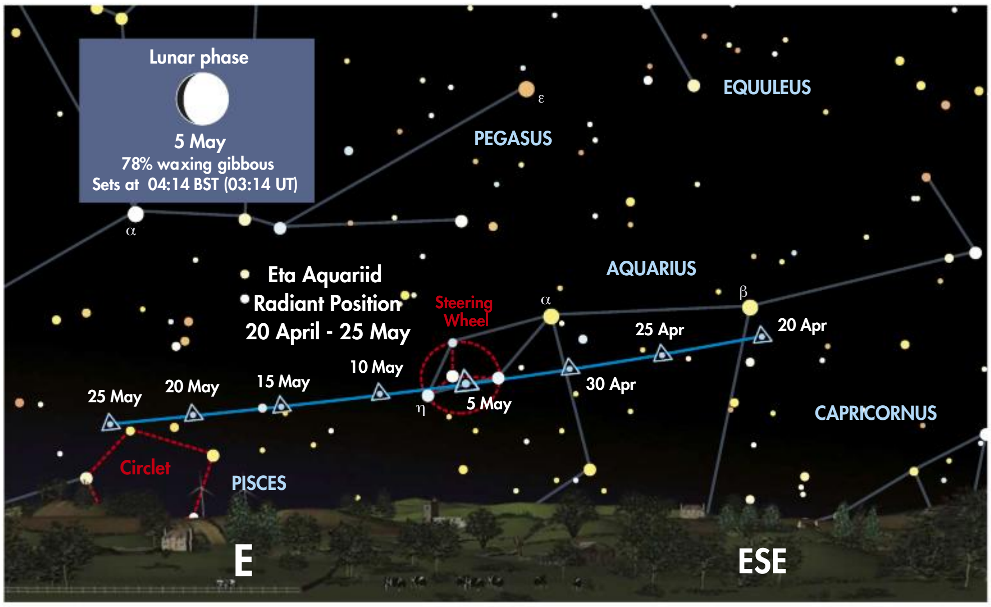
1 MAY Nice libration for viewing details on the east and northeast limb of the Moon

5 MAY Peak activity for the Eta Aquariid meteor shower

21 MAY Start looking for noctilucent cloud displays in deep twilight

22 MAY Use a 16% lit waning crescent Moon to help you find the way to see Venus during the day

31 MAY A 41% lit waxing crescent Moon lies close to the star Regulus in the daytime sky



⮝ The Steering Wheel, or Water Jar asterism meets the Eta Aquariids meteor shower in early May

The nights of May, June and July may be warm but they're also short, which makes stargazing a bit of a challenge. There are some lovely things to see though, including the constellation of Libra and the planet Venus.

KEY SIGHTS TO SEE

The Northern Crown

The bright orange star Arcturus dominates the view to the south. When Arcturus is due south, Boötes is almost vertical in the sky. Look east of its eastern 'shoulder' to find a semi-circle of stars known as Corona Borealis, the Northern Crown. The brightest star in this celestial arc is Gemma.

The Dragon

Draco, the Dragon, sits between Boötes and Polaris. The dragon winds itself around the constellation of Ursa Minor, the Little Bear, which has Polaris as its alpha star. Draco's winding body ends with a pattern of four stars as the dragon's head, known as the Lozenge.

The Strongman

Southeast of the Lozenge lies Hercules, the Strongman, a pattern of stars that on traditional charts looks like an upside-down stick figure running towards Boötes. At first glance, the star Rasalgethi appears to be the stick figure's right foot but it's actually Hercules's head.

The Scales

South of Boötes is Virgo, the second largest constellation in the sky. Its form is a large semi-circular bowl to the northwest joined to a roughly rectangular body. The stars forming the eastern side of the pattern are Mu (μ) Virginis to the south and 109 Virginis to the north. Both are pretty dim. Further southeast is a pair of brighter stars – the Scales – part of Libra. The upper star is Beta (β) Librae, or Zubeneschamali, and the southern is Alpha (α) Librae or Zubenelgenubi. Translated as the Northern and Southern Claws, this refers to the fact that Libra was once part of Scorpius, which is just rising on our chart, southeast of Libra.

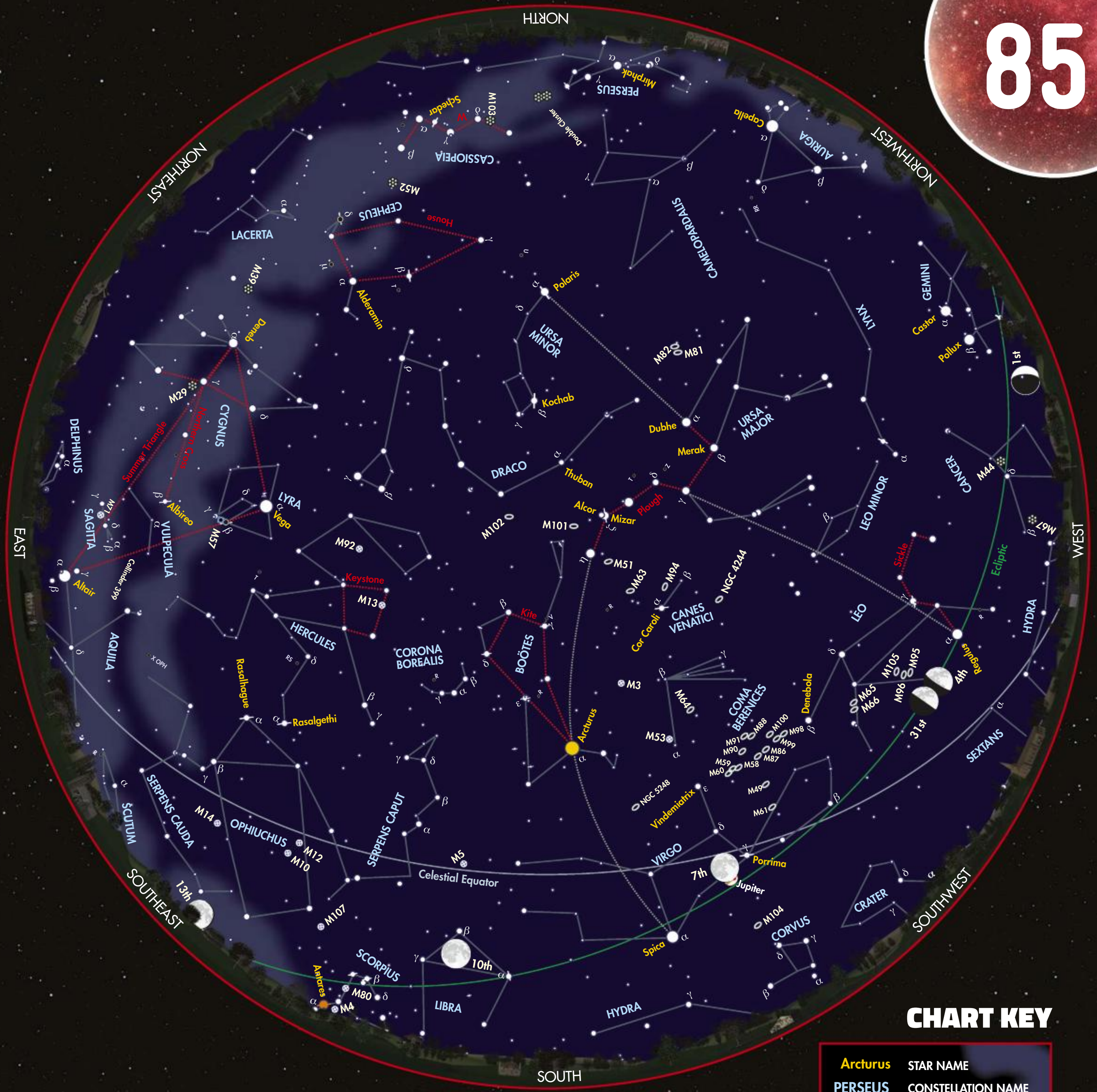
Eta Aquariid meteor shower

The meteor shower peaks on 5 May with up to 50 meteors per hour. There's a bright 79% lit waxing gibbous Moon up during peak night but this is low in the west as the shower radiant rises around 02:30 BST (01:30 UT).

Venus

On 22 May, if you can see the 16% lit waning crescent Moon in the daytime sky using just your eyes, it should be possible to find Venus nearby. The Moon is due south around 10:00 BST (09:00 UT), with Venus 4.2°, or 8 apparent Moon diameters, to the north-northeast.

CHARTS: PETE LAWRENCE



MOON PHASES Key stages in the monthly cycle

FIRST QUARTER MOON
3 May

FULL MOON
10 May

LAST QUARTER MOON
19 May

NEW MOON
25 May

VISIBLE PLANETS Where to spot the planets this month

MERCURY
Reaches the point furthest west of the Sun on 17 May, but not well placed this month

VENUS
Bright in the mornings, rising 90 minutes before the Sun by the end of the month

MARS
Visible in the evenings, gradually becoming lost from view in the dusk twilight

JUPITER
Well positioned at the start of May but losing ground to the short nights by month end

SATURN
Visible in the mornings to the northwest of the Teapot asterism in Sagittarius

URANUS
Visible in the mornings but not well positioned: never appears in true darkness all month

NEPTUNE
Not visible this month

CHART KEY

Arcturus	STAR NAME
PERSEUS	CONSTELLATION NAME
⬭	GALAXY
◌ ❄	OPEN CLUSTER
⊕	GLOBULAR CLUSTER
✧	PLANETARY NEBULA
□	DIFFUSE NEBULOSITY
●	DOUBLE STAR
○	VARIABLE STAR
◐	THE MOON (SHOWING PHASE)
☄	COMET TRACK
☄	ASTEROID TRACK
⋯	STAR-HOPPING PATH
△	METEOR RADIANT
Circlet	ASTERISM
←	MILKY WAY
🪐	PLANET

STAR BRIGHTNESS:
MAG. 0 & BRIGHTER
MAG. +1
MAG. +2
MAG. +3
MAG. +4 & FAINTER

BINOCULAR TOUR MAY

Use the chart on the right to find six fine binocular sights

☑ Tick the box when you've seen each one

1 NGC 7243 10x50s

In a bright part of the Milky Way, 2.5° west of mag. +3.8 Alpha (α) Lacertae, is NGC 7243, also known as Caldwell 16. It is a large, sparse cluster that stands out in small binoculars, even against the rich background. A pair of 10x50s should reveal a dozen stars but no background glow, suggesting that more of the stars can be seen. The stars appear to be in two groups, raising the question of whether this is a single or double cluster, or even just a chance association of stars that are not gravitationally bound.

☐ **SEEN IT**

2 M39 10x50s

From NGC 7243, locate mag. +1.3 Deneb (Alpha (α) Cygni) and move half way to it. Here you will find the sparse but bright (mag. +4.6) cluster M39. Although it is just visible to the naked eye in a dark sky, 10x50 binoculars will show you a wedge-shaped group of stars, whose number increases in better sky conditions. Although only four or five may be visible in an urban sky, a dark rural sky should allow you to glimpse 15-20 in an area about the size of the Moon. These fainter stars also change the apparent shape of the cluster from a wedge to a triangle.

☐ **SEEN IT**

▲ The open cluster IC 01396 is a fascinating star-forming region

3 IC 1396 10x50s

Slightly more than 1° south of mag. +4.0 Mu (μ) Cephei is the mag. +3.5 open cluster IC 1396. The cluster itself is over 1° wide, making it an ideal binocular object. If you return to it every hour or so as it rises higher in the sky, you should be able to see the effect of reduced atmospheric absorption, meaning more stars become visible. Although binoculars will not show any of the gas and dust associated with it, this is a star-forming region containing some of the youngest stars ever observed.

☐ **SEEN IT**

4 31 CYGNI 10x50s

Our next target is 1° north of the middle of a line joining Deneb and mag. +6.2 Delta (δ) Cygni. You are looking for a naked-eye double star; these are 31 and 30 Cygni. Through binoculars, the more southerly of the two (mag. +3.9 31 Cygni) shows a deep yellow-orange colour. This itself is a double star, with a brilliant white mag. +7.0 companion star that's easy to separate to the south. These three stars are a line-of-sight grouping and are not gravitationally connected.

☐ **SEEN IT**

5 M29 15x70s

If you put mag. +2.2 Sadr (Gamma (γ) Cygni) at the north of your field of view, you will find the mag. +6.6 open cluster M29 near the centre, just less than 2° south of the star. Although it is a fairly unremarkable object in smaller binoculars, on a good night 15x70s will show you up to a dozen stars against a diffuse background that is similar in appearance to a globular cluster. Some of these brighter stars appear to make a waisted 'H' shape. Like many clusters, its distance is unknown, but is in the range of 4,000-7,200 lightyears.

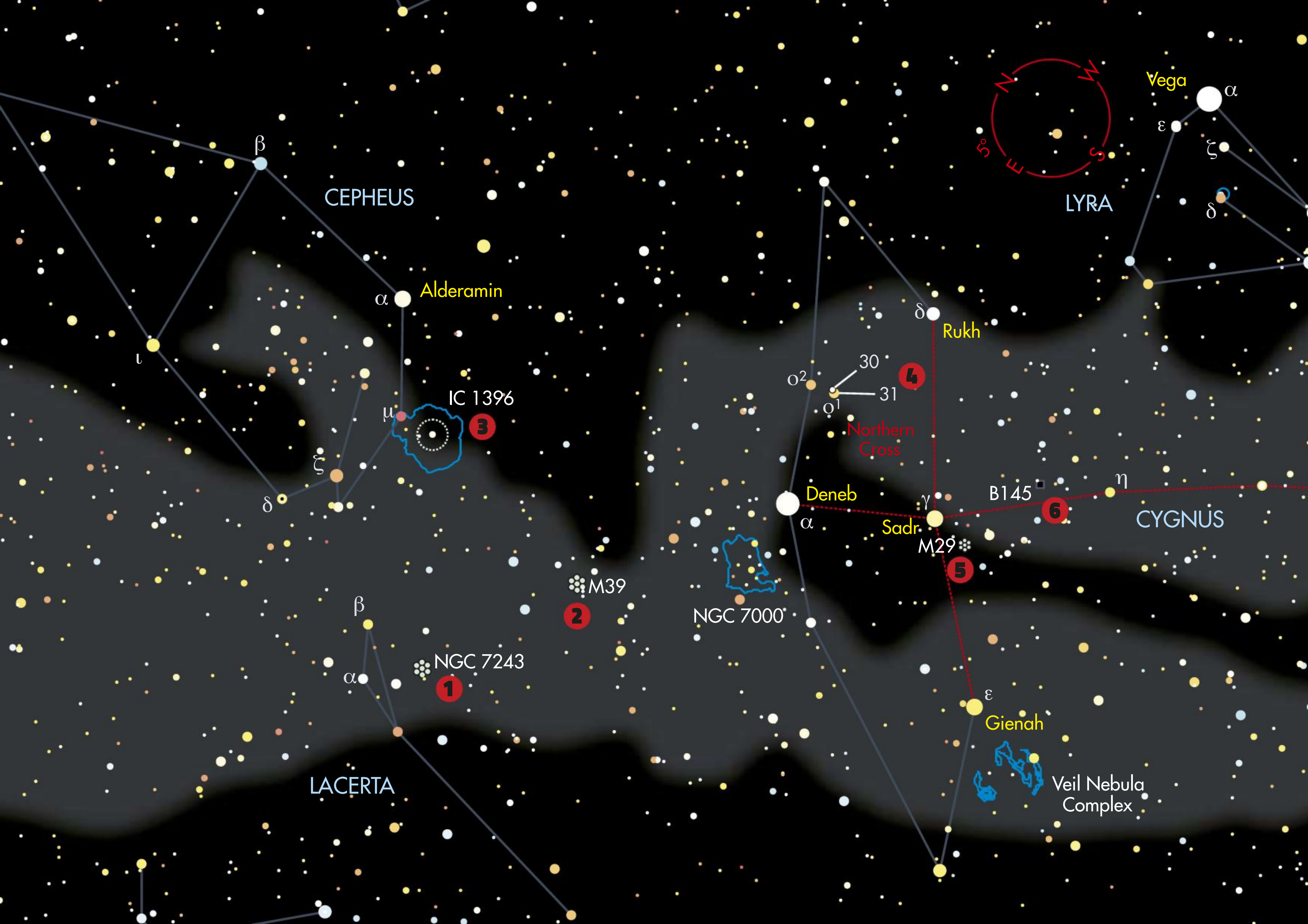
☐ **SEEN IT**

6 BARNARD 145 15x70s

Our final object is one of several dark patches of sky that American astronomer EE Barnard (1857–1923) classified as 'holes' and 'lanes' cutting through the Milky Way, before he realised that they were dust blocking out the stars behind. To locate it, start at mag. +3.9 Eta (η) Cygni and find the 6th-magnitude star that is 1° to the north. Look 1° farther on and slightly east of north to find a pair of 5th- and 6th-magnitude stars. Now glance 1° to the north you will find a long, thin 'inlet' into the Milky Way – this is Barnard 145.

☐ **SEEN IT**

JON HICKS, CHRISTOPH KALTSEIS/CCDGUIDE.COM, CHART: PETE LAWRENCE


CEPHEUS
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M39
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NGC 7000
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Veil Nebula
Complex
LACERTA

STARGAZING GUIDE JUNE

June sees a comet at its brightest and high-flying clouds

KEY DATES

1-15 JUNE Comet C/2015 V2 Johnson will be at its best magnitude of +6.7

1 JUNE Look out for the Lunar X from 22:00 BST (21:00 UT)

3 JUNE All four Galilean moons are close to Jupiter's disc at 22:30 BST (21:30 UT)

9 JUNE The Moon illusion may make tonight's rising full Moon look huge

The Sun reaches the summer solstice on 21 June, when it appears not to change position in the sky. The June solstice is when the Sun is at its greatest northern declination and is highest in the northern hemisphere's sky. This means that UK nights are at their shortest so it's a tricky month for stargazing. But, in summer we get to see the Milky Way high in the sky with bright, distinct constellations containing some great deep-sky objects. Centre stage is the late-spring constellation of Hercules, a large and sprawling group of stars with the distinctive Keystone pattern lying at its centre.

KEY SIGHTS TO SEE

M13

The Keystone asterism is a useful locator for one of the northern hemisphere's brightest globular clusters, M13, the Great Globular in Hercules. This magnificent object can just be seen with the naked eye under dark-sky conditions.

Rasalgethi

Hercules's head is at the bottom of the constellation, marked by the star Rasalgethi. Rasalgethi sits near another 'head' star called Rasalhague, representing the head of Ophiuchus, the Serpent Bearer. Ophiuchus is rectangular with a squat triangle on top and although it's a large constellation, it's a hard shape to make out.

The Serpent's Head and Tail

Being a bearer of serpents, Ophiuchus is depicted carrying the snake Serpens. This is a unique constellation because it is split in two. To the east of Ophiuchus lies Serpens Cauda, the Serpent's Tail, with Serpens Caput, the Serpent's Head, to the west. Below Ophiuchus is the beautiful orange star Antares, located at the heart of Scorpius. Saturn can currently be seen in the southeast corner of Ophiuchus, looking slightly yellow when compared with orange Antares.

High-flying clouds

June and July are the best months to look for noctilucent clouds. These are the highest clouds on the planet, being 76-85km up. They're thought to form when water freezes around the tiny particles left after a meteor vaporises in the atmosphere. They can typically be seen 90-120 minutes after sunset low in the northwest, or a similar time before sunrise low in the northeast.

Comet C/2015 V2 Johnson

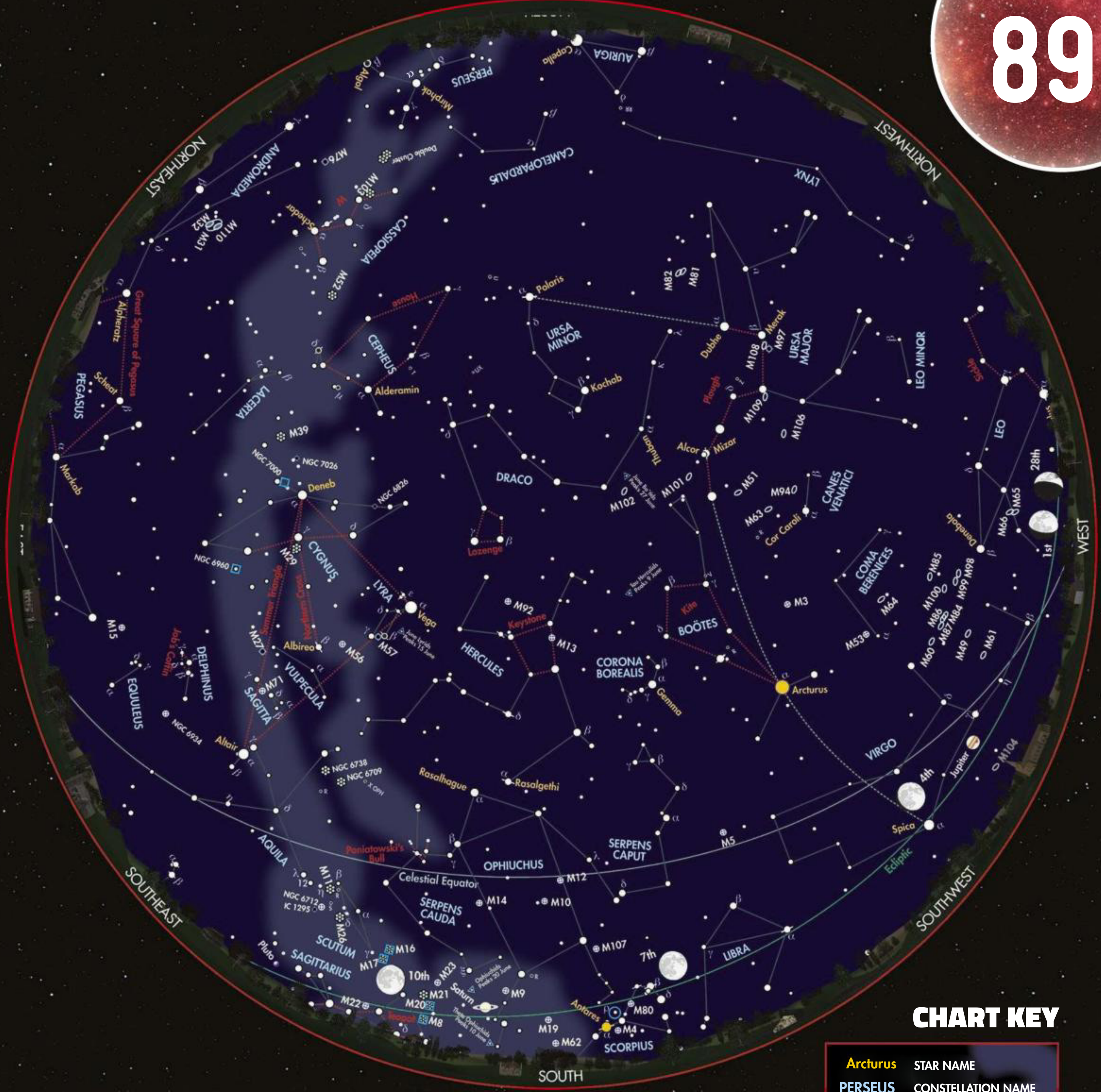
Comet C/2015 V2 Johnson moves from Boötes down into Virgo this month. The comet is due at its brightest predicted magnitude of +6.7 during the first half of June, making it a good binocular target.

Jupiter's moons

The Galilean moons Io, Europa, Ganymede and Callisto are the four largest moons of Jupiter. They take their names from the lovers of Zeus and are among the largest objects in the Solar System, with the exception of the Sun and the eight planets. All four moons are close to Jupiter's disc at 22:30 BST (21:30 UT) on 3 June.

ISTOCK, CHART: PETE LAWRENCE

Noctilucent clouds are only observable during the summer when the Sun is below the horizon but the clouds are still in sunlight



MOON PHASES Key stages in the monthly cycle

FIRST QUARTER MOON
1 Jun

FULL MOON
9 Jun

LAST QUARTER MOON
17 Jun

NEW MOON
24 Jun

VISIBLE PLANETS Where to spot the planets this month

MERCURY
Visible in the evenings after superior conjunction on 21 June

VENUS
Visible in the mornings and furthest west of the Sun on 3 June

MARS
Can't be seen this month as it's an evening object too close to the Sun

JUPITER
Best at the start of June with the Moon close by on 3rd and 30th; visible evenings

SATURN
Reaches opposition on 15 June when it will appear at its best for 2017

URANUS
Visible in the mornings but not very well positioned at present

NEPTUNE
Best in the mornings, low in the east-southeast at the end of the month

CHART KEY

Arcturus	STAR NAME
PERSEUS	CONSTELLATION NAME
⬭	GALAXY
◌ ❋	OPEN CLUSTER
⊕	GLOBULAR CLUSTER
☼	PLANETARY NEBULA
□	DIFFUSE NEBULOSITY
●	DOUBLE STAR
○	VARIABLE STAR
◐	THE MOON (SHOWING PHASE)
☄	COMET TRACK
☄	ASTEROID TRACK
⋯	STAR-HOPPING PATH
△	METEOR RADIANT
Circlet	ASTERISM
←	MILKY WAY
🪐	PLANET

STAR BRIGHTNESS:

●	●	•	·	·
MAG. 0 & BRIGHTER	MAG. +1	MAG. +2	MAG. +3	MAG. +4 & FAINTER

BINOCULAR TOUR JUNE

Point your binoculars up high for summer night sky treats

☑ Tick the box when you've seen each one

1 MELOTTE 186 10x50s

Our tour begins with an easy object – open cluster Melotte 186, which is also known as Collinder 359. It spans 4° and so is comfortably contained in the field of view of a pair of 10x50s and seems to be made for binoculars. The cluster includes a prominent 'V' of five stars: 66, 67, 68, 70 and 73 Ophiuchi. This shape looks like the Hyades cluster in Taurus, a similarity that led to this region being called Taurus Poniatovii (Poniatowski's Bull) in the 18th century. One particularly striking thing about Melotte 186 is the variety of colours of its brighter stars.

☐ **SEEN IT**

2 THE SUMMER BEEHIVE 10x50s

The Summer Beehive, officially IC 4665, is the classic cluster of the summer skies. Look for a particularly attractive curved chain of bright white stars, which forms part of the letter 'H' in the inverted word 'HI'. This large cluster, which is in the same field of view as mag. +2.8 Cebalrai (Beta (β) Ophiuchi), can be seen well in binoculars of any size. You should easily be able to make out about a dozen stars with a pair of 10x50s.

☐ **SEEN IT**

⮝The Eagle Nebula, M16, is also known as the Star Queen Nebula

3 M12 10x50s

Globular cluster M12 lies very close to the northeast point of an equilateral triangle that has two stars – mag. +2.7 Yed Prior (Delta (δ) Ophiuchi) and mag. +2.5 Zeta (ζ) Ophiuchi – as the other points. Shining at mag. +6.7, it is one of the larger and brighter southern globular clusters visible from the UK. It's an easy object to find with 10x50 binoculars in moderately good skies, though its core is very indistinct for a globular cluster and it was once believed to be a compact open cluster. It's now thought that many of its low mass stars have been stripped away by the gravity of the Milky Way.

☐ **SEEN IT**

4 M10 10x50s

Put M12 at the northwest of the field of view and the next target, globular cluster M10, should be near the opposite side of the field. It's approximately the same size as M12 but slightly brighter. These globular clusters are a good opportunity for you to try 'averted vision'. Put both M10 and M12 in the field of view and, when you direct your gaze to one of them, you should notice the other grow and brighten.

☐ **SEEN IT**

5 THE EAGLE NEBULA 15x70s

To find the Eagle Nebula, M16, place mag. +4.7 Gamma (γ) Scuti in the southeast of the field of view and the cluster will be just west of centre. This object was made famous by the 'Pillars of Creation' image taken by the Hubble Space Telescope in 1995, showing gas and dust in the process of creating new stars. But unless your skies are very good you're unlikely to be able to see any of the nebulosity – just the cluster. If you have an ultra high contrast filter, try holding it over one of the eyepieces to make the nebulosity visible – you may be able to identify the shape of the wings and tail from which this object gets its name.

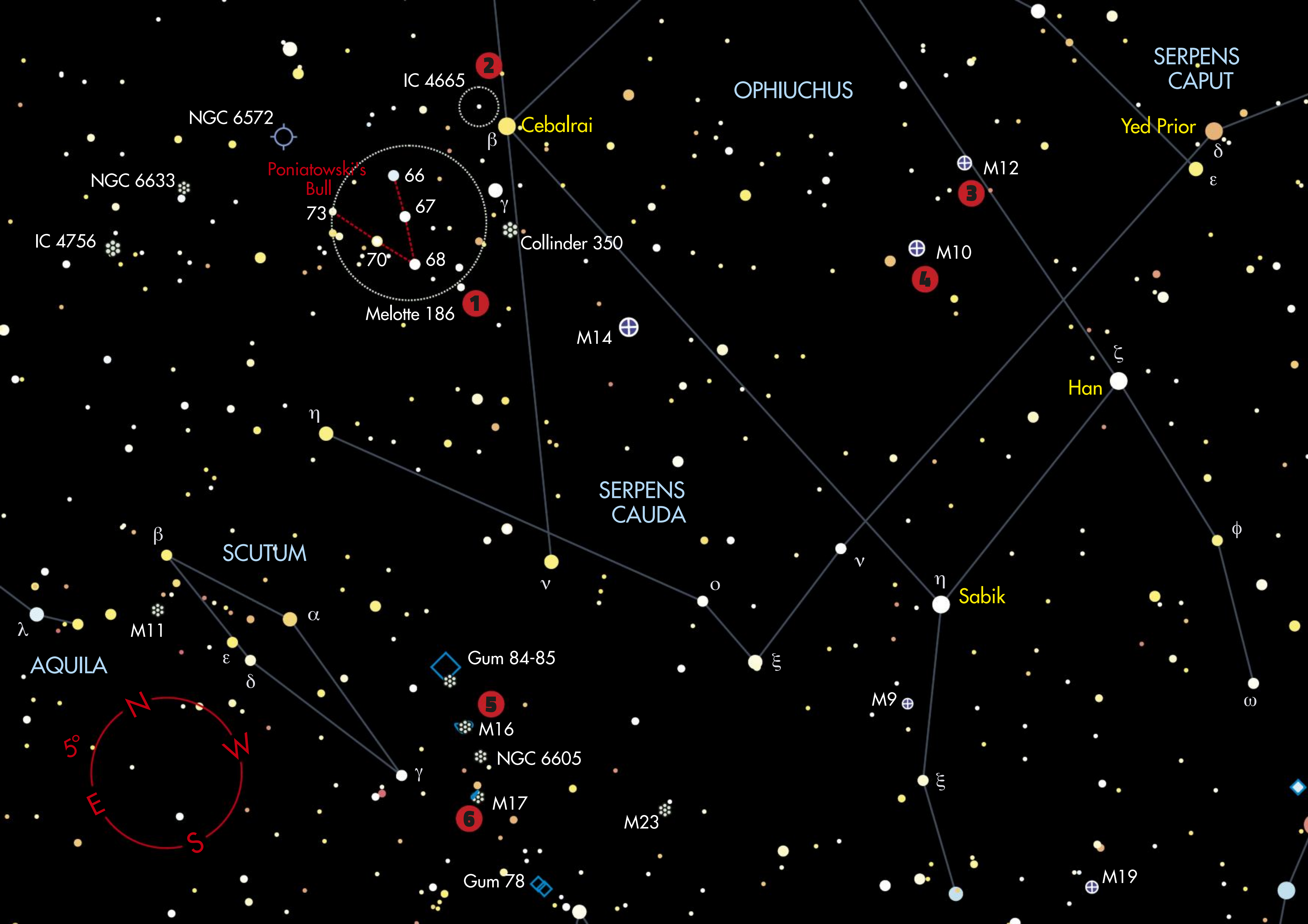
☐ **SEEN IT**

6 THE SWAN NEBULA 15x70s

Move 2.5° south of M16 to find the Swan Nebula, also known as the Omega Nebula and Messier 17. You should initially see an elongated oval patch of greyish light about 10 arcminutes long. Keep it centred while you look at the mag. +5.3 star about 0.5° north of it, and averted vision should reveal a small hook-like extension stretching south from the top of the patch. This makes it look like an inverted tick-mark.

☐ **SEEN IT**

HARALD STRAUSS/CCDGUIDE.COM, CHART: PETE LAWRENCE


SERPENS
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Gum 78
M19

SPRING TARGET

MELOTTE 111

This nearby open cluster reveals lovely detail and coloured double stars through binoculars and telescopes

NAKED EYE What you see just by looking up

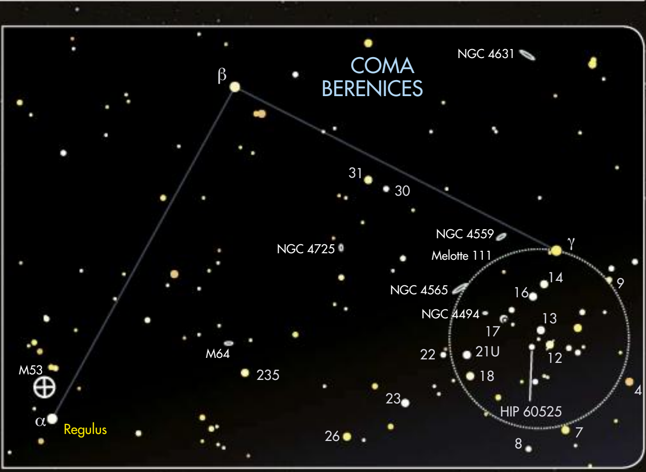
Coma Berenices is a small constellation between Leo and Boötes. In dark skies there's something quite mesmerising about it because Melotte 111, a triangular open cluster spanning 7.5º, forms part of the constellation which represents the hair of Egyptian Queen Berenice II. Legend tells how she bargained with Aphrodite that if her husband, King Ptolemy III, returned from Syria safely she would sacrifice her hair. He did and she kept her bargain, announcing that Aphrodite had placed her hair among the stars. This came at the expense of the tuft of Leo's tail, which was reassigned to Coma Berenices. The cluster begins at the mag. +4.3 star Gamma (α) Comae Berenices and then appears to flow and expand as it heads south.

BINOCULARS More detail and a wide field view

Binoculars bring order to the cluster, allowing your eyes to view a reasonable number of its 100 or so members. A pair of 7x50 binoculars shows the whole cluster in one go. Placing Gamma Comae at the top of view, the other stars cascade south. The eastern side is defined by the stars Gamma 14, 16, 17, 21, 18, 22, 23 and 26 Comae. The triangle's western edge is less clear. The two mag. +5.0 stars, 13 and 12 Comae, together with mag. +6.4 HIP 60525, form a northwest 'shoulder', but then structure is lacking until you arrive at mag. +4.9 star 7 Comae in the southwest. This is a close open cluster to Earth, estimated to be 288 lightyears away and 400 million years old. Its appearance is sparse; indeed it wasn't recognised as a true cluster until 1938.

TELESCOPE Upping the magnification gives more detail

An eyepiece's narrow view can miss the stars in the cluster, so low magnifications can look for objects more suited to higher powers in the cluster's shape. There are many double stars in Coma, some located in the cluster. Mag. +4.8 12 Comae is one, with a 66 arcsecond separation and mag. +5.0/+8.0 components. A third mag. +11.0 component lies 35 arcseconds northeast. 17 Comae is another target with a wide separation of 145 arcseconds and components of mag. +5.5/+6.5. The real show-stopper is 24 Comae, which lies south of Melotte 111. This double has an orange mag. +5.0 primary and blue mag. +6.5 secondary, separated by 20 arcseconds. The more distant but glorious mag. +11 NGC 4565 is an edge-on spiral galaxy.



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STATS

NAME: The Coma Star Cluster
CATALOGUE REFERENCE: Melotte 111
CONSTELLATION: Coma Berenices
OBJECT TYPE: Open cluster
VISUAL BRIGHTNESS: Mag. +1.8 (naked eye)
DISTANCE: 288 lightyears
APPARENT SIZE: 7.5º
PHYSICAL SIZE: 30-35 lightyears across

Once the tail-end of Leo, the triangular Coma Cluster is now part of the Coma Berenices constellation

SPRING TARGET

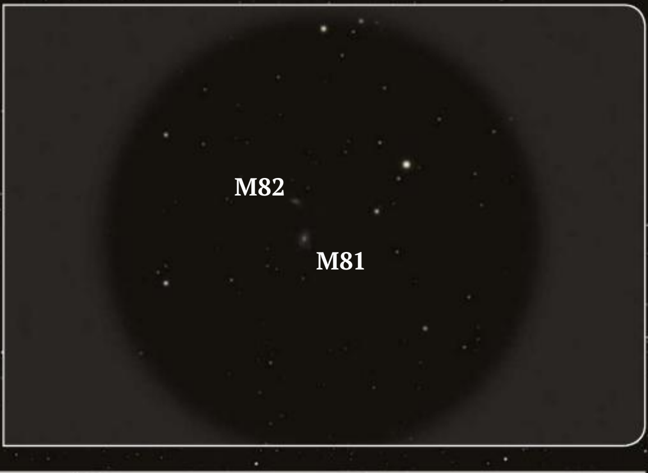
M81/M82

BODE'S GALAXY AND THE CIGAR GALAXY

Increasing magnification takes these two galaxies from oval smudges to reveal spiral arms and fine mottled structure

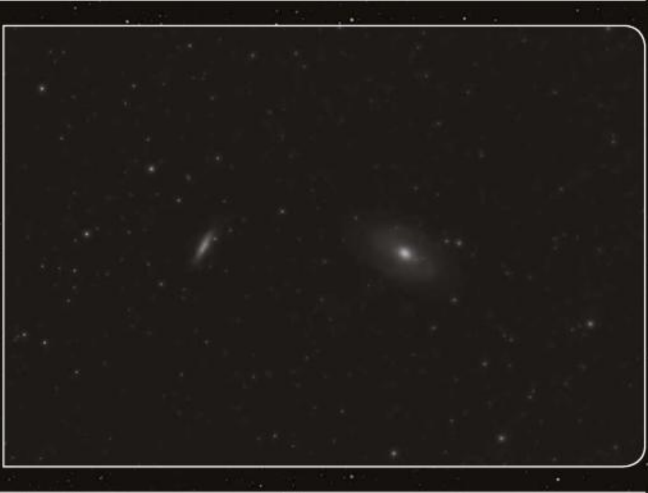
BINOCULARS More detail and a wide field view

Messier 81 and 82 are a pair of relatively bright galaxies near the Plough. Find them by drawing a diagonal line from the star in the southeast of the ploughshare, mag. +2.4 Gamma (γ) Ursae Majoris, or Phecda, through the star in the northwest corner, mag. +1.8 Alpha (α) Ursae Majoris, or Dubhe. Extend this line for the same distance again and both galaxies should be in the field of a pair of binoculars (light pollution and binocular size will make a difference). M81, or Bode's Galaxy, should be the most obvious, appearing as an oval smudge. M82, or the Cigar Galaxy, can be harder to pick out, being both smaller and fainter than M81. Larger binoculars fare better – a 15x70 pair of binoculars will show both objects well.



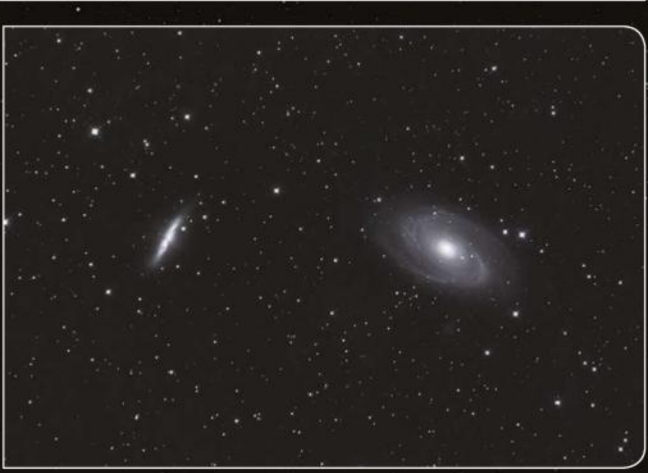
SMALL SCOPE Up the magnification for more detail

A small telescope reveals both galaxies well. Despite their proximity on charts, they are 36 arcminutes apart and it's fairly common to see one galaxy while the other is out of view. Use a low power, with which the Moon takes up less than 80% of the field of view, and you will get a decent view of both galaxies together. M81 has a star-like core around which the galaxy's central bulge appears as a glowing elliptical haze. Use a magnification of 50x or more to see its delicate spiral arms. Despite being dimmer, M82's more compact nature helps define it and its thin, linear appearance is most evident. A 100mm telescope should reveal the effects of dark lanes crossing M82.



LARGE SCOPE More magnification for more detail

Large telescopes show the beauty of this pair. The core of M81 appears bright and extensive but doesn't show much visual structure. Increase magnification to study the knotted, tightly wound spiral arms; between 150-250x works well, but reduce if detail gets lost. The spiral arms should appear mottled with reasonable contrast at their edges. M82 is completely different. Here, the thin streak seen with smaller instruments is awash with fine mottled structure. This creates a broken, irregular appearance that's fascinating to study. Unlike M81, M82 doesn't appear to have an easily identifiable core. But the galaxy's central section has more prominence as the non-core sections appear to blend into the black background sky.



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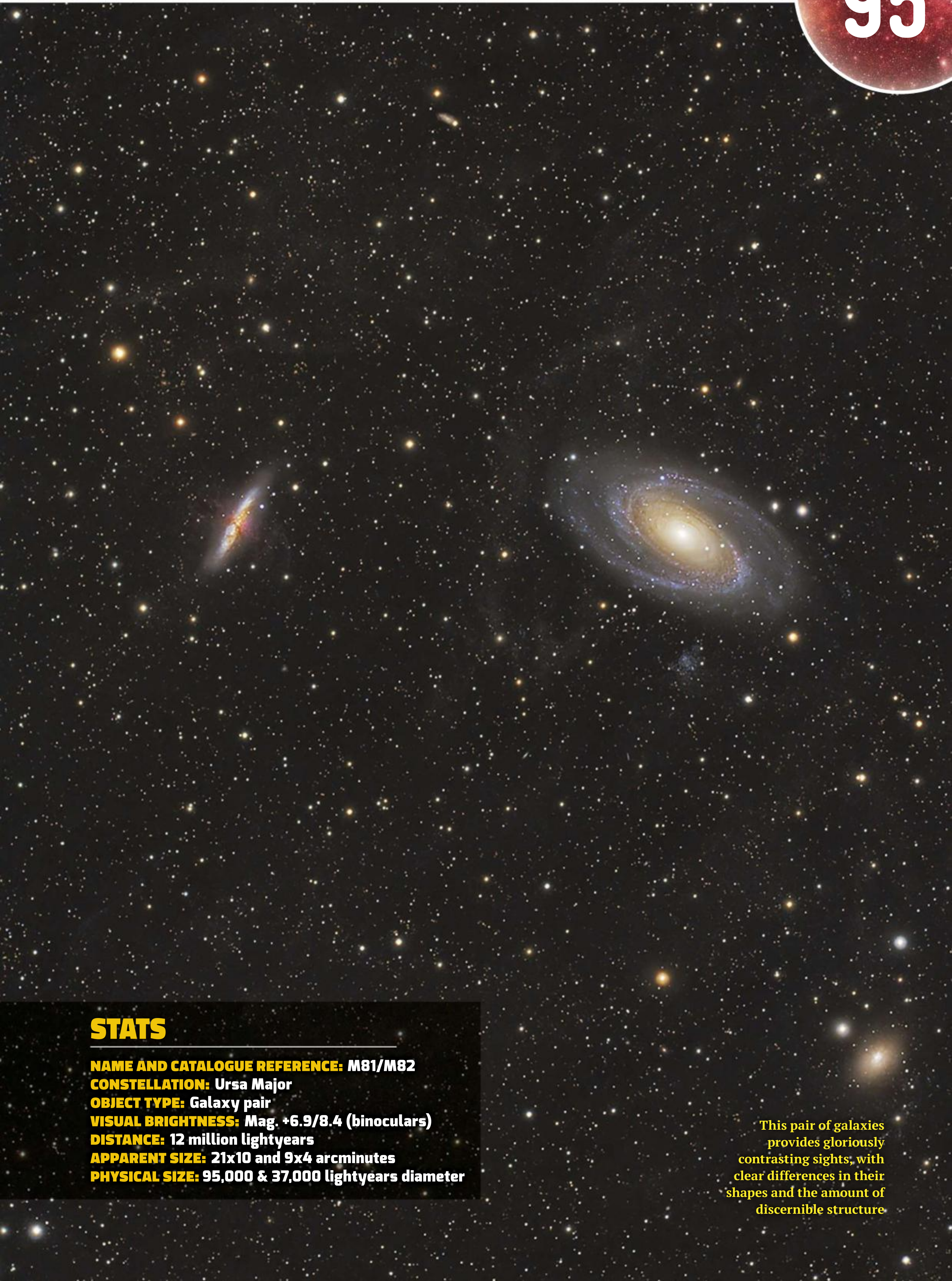


This pair of galaxies provides gloriously contrasting sights, with clear differences in their shapes and the amount of discernible structure

STATS

NAME AND CATALOGUE REFERENCE: M81/M82
CONSTELLATION: Ursa Major
OBJECT TYPE: Galaxy pair
VISUAL BRIGHTNESS: Mag. +6.9/8.4 (binoculars)
DISTANCE: 12 million lightyears
APPARENT SIZE: 21x10 and 9x4 arcminutes
PHYSICAL SIZE: 95,000 & 37,000 lightyears diameter

SPRING TARGET

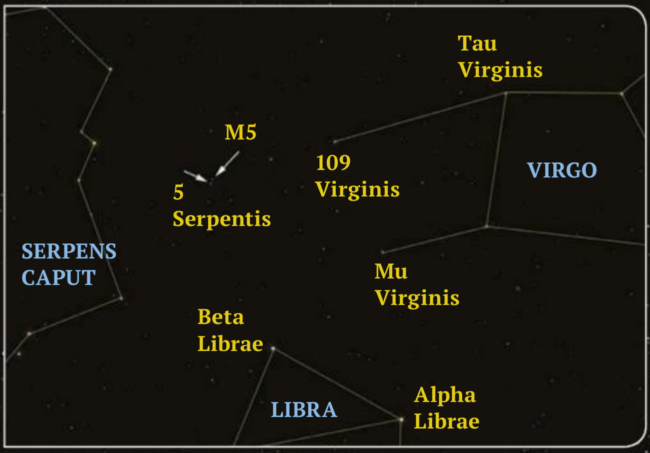
M5

GLOBULAR CLUSTER IN SERPENS CAPUT

A beautiful collection of stars that's just about visible unaided but really impresses with extra magnification

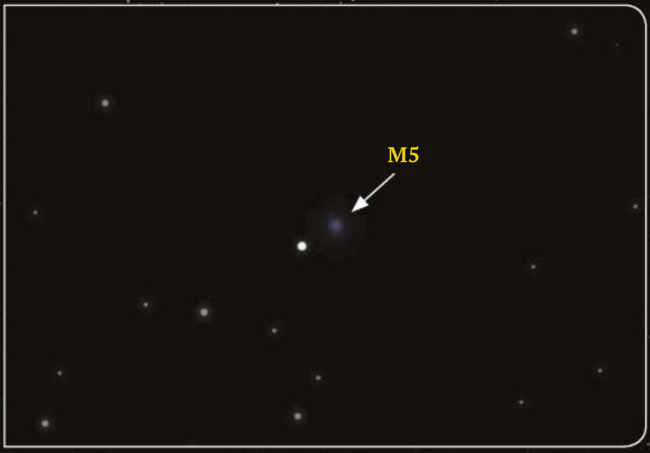
NAKED EYE What you see just by looking up

At magnitude +5.7, globular cluster M5 is about as faint as you can see with the naked eye. If you have very dark and clear skies it is possible to see it, resembling a very faint star right on the edge of sight. From the UK, M5 never really gets very high in the sky, only reaching a maximum altitude of 38° when due south. This means that some of its light is lost to the atmosphere, which makes spotting it just that little bit harder. The easiest way to track it down is to look for the two similarly bright stars in Libra that lie to the east of bright Spica in Virgo. Imagine the line they make as the bottom-right spoke in a three-spoke steering wheel. M5 would be located just above where the top of the upper spoke would lie.



BINOCULARS More detail and a wide field view

Through binoculars, M5 looks like a fuzzy star. No matter how hard you try, it just won't focus to a point. Use the Libra trick mentioned in the naked eye description to get in the right part of the sky. Alternatively, the two stars that mark the northeast part of the stick figure of Virgo – that's Tau (τ) Virginis and 109 Virginis – point directly towards M5. Once you're looking in the right place, there's a fifth magnitude star called 5 Serpentis which can cause confusion – M5 is actually located 22 arcminutes, or two-thirds of the apparent diameter of the Moon, to the northwest of the star. Once you know this, 5 Serpentis is a handy way to locate M5 and a good comparison because, of course, it does focus to a sharp point.



TELESCOPE Upping the magnification gives more detail

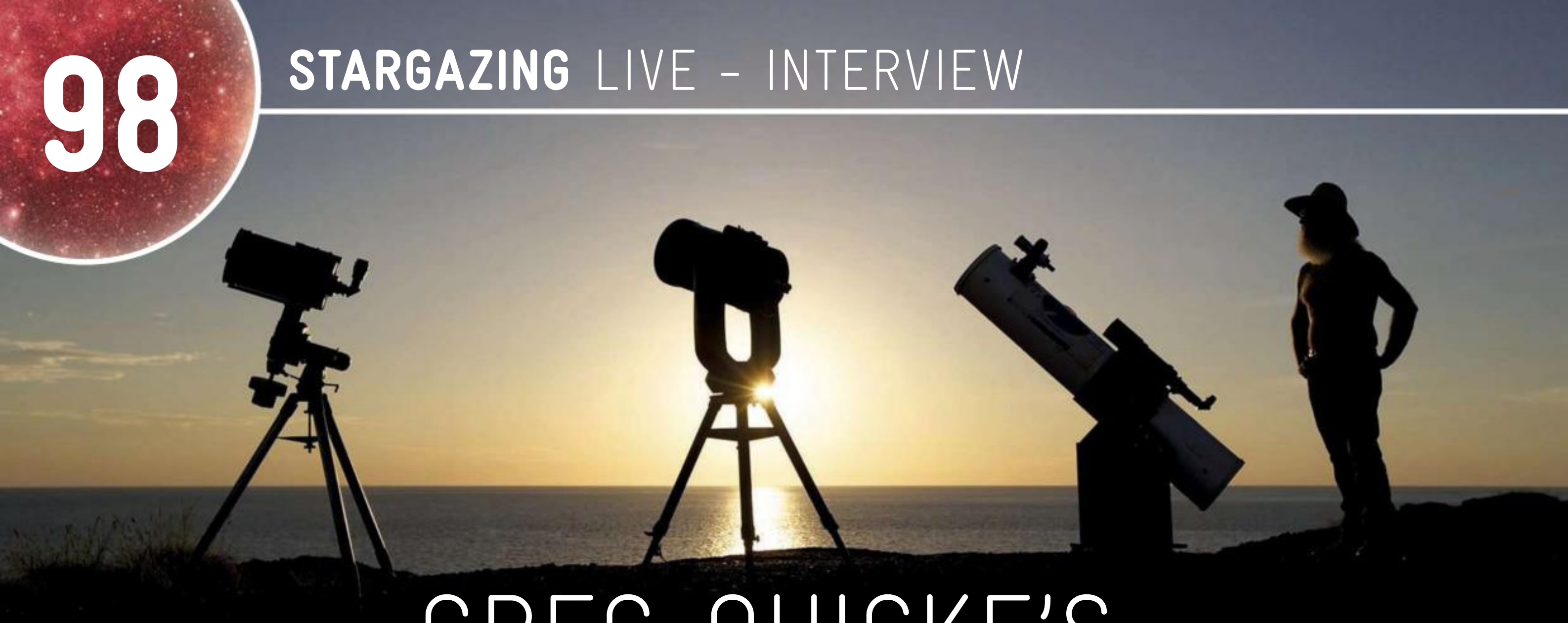
Through a telescope M5 really comes alive. A 150mm scope will show it as a fuzzy patch with granularity around the edges at low powers. Pile on the magnification and the central condensation starts to resolve into individual stars. A 250mm scope resolves most of these stars and reveals a number of lovely strings of stars running out from, and across, the core. At this aperture M5 appears to have an apparent diameter of around 12 arcminutes. The core itself remains fuzzy, but looks more granular with increasing aperture. Fewer stars appear in the outer parts of the cluster to the east, which makes M5 look a little lopsided. This is a great object to study with a telescope, so take your time and really soak in all those stars.

JOHANNES SCHEDLER/CCDGUIDE.COM, PETE LAWRENCE X 3

The brightest variable in M5 changes from mag. 10.6 to mag. 12.1 in about 26 days

STATS

NAME: M5
CATALOGUE REFERENCE: NGC 5904
CONSTELLATION: Serpens Caput
OBJECT TYPE: Globular cluster
VISUAL BRIGHTNESS: Mag. +5.7
DISTANCE: 24,500 lightyears
APPARENT SIZE: 23 arcminutes
PHYSICAL SIZE: 160 lightyears across

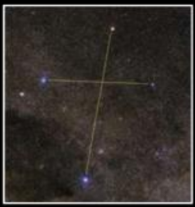


GREG QUICKE'S
SOUTHERN SKIES

Aussie astronomer Greg Quicke took time out from filming *Stargazing Live* to tell us more about his favourite sights in the southern night sky

Southern hemisphere skies have a whole bunch of galactic and intergalactic objects that you simply cannot see from the northern hemisphere of the world, unless you travel Down Under. Australia is perfectly positioned on our little planet to be pointed in the direction of some incredible celestial delights. Here are some of my favourites.

THE SOUTHERN CROSS

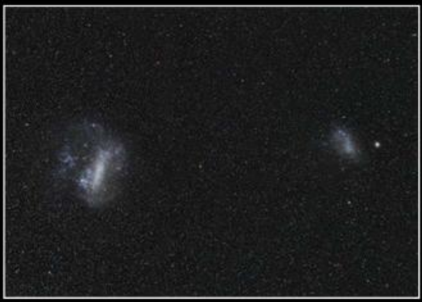


Even though the Southern Cross is well known to people all over the world, not many people know how to find it in the sky. It is smaller than most people expect and there are any number of crosses in the sky to confuse it with. Finding the pointer stars of Alpha and Beta Centauri is the key to becoming familiar with this most beautiful timekeeper of the southern skies.

ALPHA CENTAURI

If we took a journey to the closest star we can see and then looked back from there to our own Sun, we would see a star that looked very similar to the way Alpha Centauri appears to us from Earth. At only 4.3 lightyears away, this third brightest star in our skies is the same brightness as our Sun. Getting up close to this deep southern star with a telescope reveals that Alpha Centauri is one of the most beautiful double stars in the sky.

LARGE AND SMALL MAGELLANIC CLOUDS



The Clouds of Magellan look like two pieces broken off the Milky Way. They are clearly visible to the naked eye on a dark moonless night, quite separate from the main sweep of our Galaxy. The northern hemisphere has no equivalent to this pair of baby galaxies lying only a couple of hundred thousand lightyears away. They are far too big in the sky to fit in the field of view of most telescopes, so binoculars are your best friend for scanning around and finding clusters and nebulae embedded within them.

SCULPTOR GALAXY

The dwarf galaxies of Magellan are pretty close to us compared to any full-sized galaxies in our neighbourhood. At 11.5 million lightyears away, NGC 253 is easy enough to pick out in the 10x50 finder of a 16-inch Dobsonian. A little star hopping from the second magnitude star, Diphda, and you'll find it easily. A 21mm eyepiece on the main scope brings this near edge-on starburst galaxy right into your life. While the Sculptor Galaxy does graze your southern horizon from the UK, you'll have to go south to see it with any clarity.

THE JEWEL BOX

With its traffic light stars of different colours, the Jewel Box or NGC 4755 is one of the most beautiful compact galactic open star clusters in the sky. It's easily found with binoculars next to the leftmost star of an upright Southern Cross. Closing in with a 13mm eyepiece in a 10-inch Dobsonian telescope, it will blow your mind when you realise that every one of the 100 or so stars you can see is an entire planetary system.

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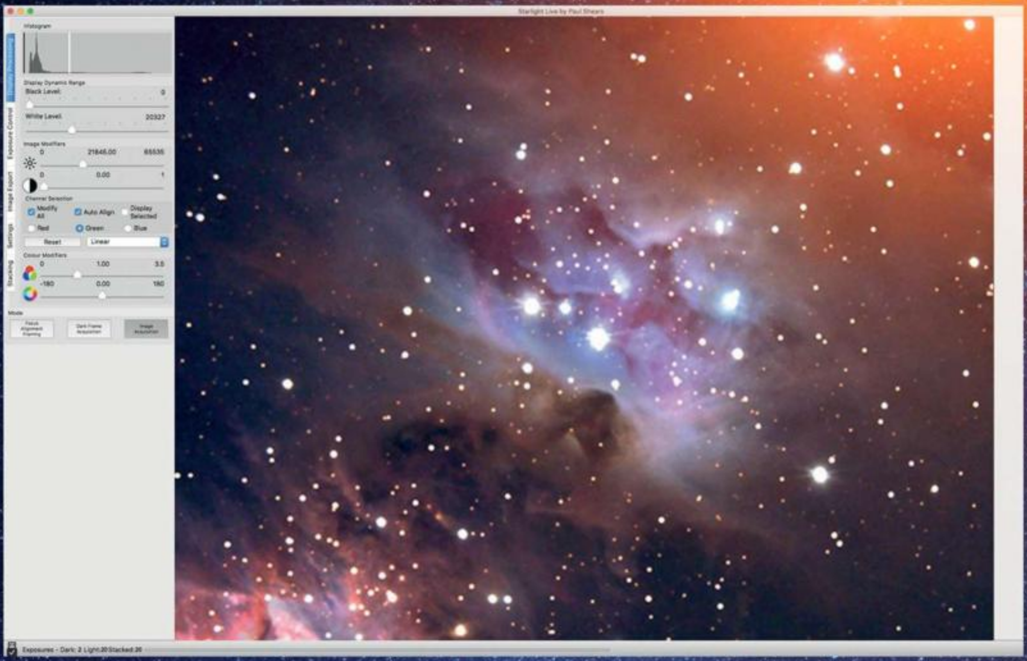

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